11-28-00





A

**Practitioner's Docket No.** 944-001.040 ***PATENT***

Preliminary Classification:

Proposed Class:

Subclass:

*NOTE:* *"All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.'" M.P.E.P. § 601, 7th ed.*

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**Box Patent Application**
**Assistant Commissioner for Patents**
**Washington, D.C. 20231**

## NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of

Inventor(s): Antti Lappeteläinen

***WARNING:*** *37 C.F.R.§ 1.41(a)(1) points out:*

*"(a) A patent is applied for in the name or names of the actual inventor or inventors.*

*"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(l) is filed supplying or changing the name or names of the inventor or inventors."*

For (title): ADAPTIVE TRANSMISSION CHANNEL ALLOCATION METHOD AND SYSTEM FOR ISM AND UNLICENSED FREQUENCY BANDS

---

**CERTIFICATION UNDER 37 C.F.R. § 1.10***

*(Express Mail label number is **mandatory**)*
*(Express Mail certification is optional.)*

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date November 27, 2000, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number EL628639744US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Judith R. Schick
*(type or print name of person mailing paper)*

Judith R. Schick
**Signature of person mailing paper**

***WARNING:*** *Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.*

***WARNING:*** *Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. § 1.10(b).*
*Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

## 1. Type of Application

This new application is for a(n)

(check one applicable item below)

☒ Original (nonprovisional)

☐ Design

☐ Plant

***WARNING:*** *"**Do not** use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. § 37(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application.*

***WARNING:*** ***Do not** use this transmittal for the filing of a provisional application.*

*NOTE: If one of the following 3 items apply, then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED and a NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION.*

☐ Divisional
☐ Continuation
☐ Continuation-in-part (C-I-P)

## 2. Benefit of Prior U.S. Application(s) (35 U.S.C. §§ 119(e), 120, or 121)

*NOTE: A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. § 112. Each prior application must also be:*

*(i) An international application entitled to a filing date in accordance with PCT Article 11 and designated the United States of America; or*

*(ii) Complete as set forth in § 1.51(b); or*

*(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or*

*(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(l) within the time period set forth in § 1.53(f).*

*37 C.F.R. § 1.78(a)(1).*

*NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.*

***WARNING:*** *If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. §§ 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. §§ 120,121 or 365(c). (35 U.S.C. § 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. §§ 199, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.*

***WARNING:*** *When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application* ***must*** *be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).*

☐ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

**3. Papers Enclosed**

**A.** Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

_25_ Pages of specification
_4_ Pages of claims
_21_ Sheets of drawings

***WARNING:*** ***DO NOT*** *submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 C.F.R. § 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).*

*NOTE: "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm (5/8 inch) down from the top of the page . . ." 37 C.F.R. § 1.84(c)).*

*(complete the following, if applicable)*

☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. § 1.84(b).
☐ formal
☒ informal

**B.** Other Papers Enclosed

___ Pages of declaration and power of attorney
_1_ Pages of abstract
_1_ Other (Title Page)

**4. Additional papers enclosed**

☐ Amendment to claims

☐ Cancel in this application claims __________________ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)

☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)

☐ Preliminary Amendment

☐ Information Disclosure Statement (37 C.F.R. § 1.98)

☐ Form PTO-1449 (PTO/SB/08A and 08B)

☐ Citations

- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

**5. Declaration or oath (including power of attorney)**

NOTE: *A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)-(3).*

NOTE: *A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)-(4).*

NOTE: *"The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.62, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(l) is filed supplying or changing the name or names of the inventor or inventors." 37 C.F.R. § 1.41(a)(1).*

☐ Enclosed

Executed by

(check **all** applicable boxes)

- ☐ inventor(s).
- ☐ legal representative of inventor(s). 37 C.F.R. §§ 1.42 or 1.43.
- ☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.
  - ☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F. R. § 1.47 is also attached. *See* item 13 below for fee.

☒ Not Enclosed

NOTE: *Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.*

☐ Application is made by a person authorized under 37 C.F.R. § 1.41(c) on behalf of *all* the above named inventor(s).

*(The declaration or oath, along with the surcharge required by 37 C.F.R. § 1.16(e) can be filed subsequently).*

☐ Showing that the filing is authorized.
*(not required unless called into question. 37 C.F.R. § 1.41(d))*

## 6. Inventorship Statement

**WARNING:** *If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.*

The inventorship for all the claims in this application are:

☒ The same.

**or**

☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,

☐ is submitted.

☐ will be submitted

## 7. Language

*NOTE:* *An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of $130.00 required by 37 C.F.R. § 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 C.F.R. § 1.52(d).*

☒ English

☐ Non English

☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. § 1.52(d).

## 8. Assignment

☒ An assignment of the invention to Nokia Mobile Phones Ltd.

☐ is attached. A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

☒ will follow.

*NOTE:* *"If an assignment is submitted with a new application, send two separate letters-one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).*

**WARNING:** *A newly executed "CERTIFICATE UNDER 37 C.F.R. § 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 193, 1150 O.G. 62-64.*

**9. Certified Copy**

Certified copy(ies) of application(s)

| Country | Appln. No. | Filed |
|---|---|---|
| Country | Appln. No. | Filed |
| Country | Appln. No. | Filed |

from which priority is claimed

- ☐ is (are) attached.
- ☐ will follow.

NOTE: *The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 C.F.R. § 1.55(a) and 1.63.*

NOTE: *This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. § 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.*

**10. Fee Calculation** (37 C.F.R. § 1.16)

**A.** ☐ Regular application

CLAIMS AS FILED

| Number filed | | Number Extra | | Rate | Basic Fee 37 C.F.R. § 1.16(a) $710.00 |
|---|---|---|---|---|---|
| Total Claims (37 C.F.R. § 1.16(c)) | -20 = | 0 | x | $18.00 = | |
| Independent Claims (37 C.F.R. § 1.16(b)) | - 3 = | 0 | x | $80.00 = | |
| Multiple dependent claim(s), if any (37 C.F.R. § 1.16(d)) | | | + | $270.00 | |

- ☐ Amendment canceling extra claims is enclosed.
- ☐ Amendment deleting multiple-dependencies is enclosed.
- ☐ Fee for extra claims is not being paid at this time.

NOTE: *If the fees for extra claims are not paid on filing, they must be paid or the claims canceled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 C.F.R. § 1.16(d).*

Filing Fee Calculation $________________

**B.** ☐ Design application
($320.00 – 37 C.F.R. § 1.16(f))

Filing Fee Calculation $________________

C. ☐ Plant application

($490.00 - 37 C.F.R. § 1.16(g))

Filing Fee Calculation $_______________

**11. Small Entity Statement(s)**

☐ Statement(s) that this is a filing by a small entity under 37 C.F.R. §§ 1.9 and 1.27 is (are) attached.

***WARNING:*** *"Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. § 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).*

***WARNING:*** *"Small entity status must not be established when the person or persons signing the. . . statement can* ***unequivocally*** *make the required self-certification." M.P.E.P., § 509.03, 6th ed., rev. 2, July 1996 (emphasis added).*

(complete the following, if applicable)

☐ Status as a small entity was claimed in prior application

_______/_____________, filed on ___________________, from which benefit is being claimed for this application under:

35 U.S.C. § ☐ 119(e),

☐ 120,

☐ 121,

☐ 365(c),

and which status as a small entity is still proper and desired.

☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of **A**, **B**, or **C** above)

$_______________________

NOTE: *Any excess of the full fee paid will be refunded if a small entity statement and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 C.F.R. § 1.28(a).*

**12. Request for International-Type Search** (37 C.F.R. § 1.104(d))

(complete, if applicable)

☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. **Fee Payment Being Made at This Time**

☒ Not Enclosed

☐ No filing fee is to be paid at this time.
*(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)*

☐ Enclosed

☐ Filing fee $____________

☐ Recording assignment
($40.00 – 37 C.F.R. § 1.21(h))
(See attached "COVER SHEET FOR ASSIGNMENT ACCOMPANYING NEW APPLICATION.") $____________

☐ Petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached.
($130.00 – 37 C.F.R. §§ 1.47 and 1.17(i)) $____________

☐ For processing an application with a specification in a non-English language
($130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k)) $____________

☐ Processing and retention fee
($130.00, 37 C.F.R. §§ 1.52(d) and 1.21(l)) $____________

☐ Fee for international-type search report
($40.00; 37 C.F.R. § 1.21(e)) $____________

NOTE: *37 C.F.R. § 1.21(l) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 C.F.R. § 1.53(f) and this, as well as the changes to 37 C.F.R. §§ 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(l) must be paid, within 1 year from the notification under § 53(f).*

**Total fees enclosed** **$____________**

14. **Method of Payment of Fees**

☐ Check in the amount of $____________________

☐ Charge Account No. ________________________ in the amount of $____________
A duplicate of this transmittal is attached.

NOTE: *Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 C.F.R. § 1.22(b).*

## 15. Authorization to Charge Additional Fees

***WARNING:*** *If no fees are to be paid on filing, the following items should not be completed.*

***WARNING:*** *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.*

☐ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No.____________.

- ☐ 37 C.F.R. § 1.16(a), (f), or (g) (filing fees)
- ☐ 37 C.F.R. § 1.16(b), (c), and (d) (presentation of extra claims)

NOTE: *Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims canceled by amendment prior to the expiration of the time period set for response by the P.T.O. in any notice of fee deficiency (37 C.F.R. § 1.16(d)), it might be best not to authorize the P.T.O. to charge additional claim fees, except possibly when dealing with amendments after final action.*

- ☐ 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)
- ☐ 37 C.F.R. § 1.17(a)(1)-(5) (extension fees pursuant to § 1.136(a))
- ☐ 37 C.F.R. § 1.17 (application processing fees)

***WARNING:*** *"...A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).*

- ☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: *Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the Notice of Allowance. 37 C.F.R. § 1.311(b).*

NOTE: *37 C.F.R. § 1 28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . issue fee." From the wording of 37 C.F.R. § 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.*

## 16. Instructions as to Overpayment

NOTE: *"...Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).*

☐ Credit Account No.____________________

☐ Refund

Date: NOV. 27, 2000

Reg. No. 40,061

Tel. No. (203) 261-1234

Customer No. 004955

Ken Lao

**SIGNATURE OF PRACTITIONER**

Kenneth Q. Lao

(type or print name of practitioner

Ware, Fressola, Van Der Sluys & Adolphson LLP

755 Main Street

P.O. (Correspondence) Address

P.O. Box 224

Monroe, CT 06468

☐ **Incorporation by reference of added pages**

(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.)

☐ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added ____________

☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added ____________

☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added ____________

☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added ____________

☒ **Statement Where No Further Pages Added**

*(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item.*

☒ This transmittal ends with this page.

PATENT
Attorney Docket No. 944-001.040

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION

of

**Antti LAPPETELÄINEN**

for a

**ADAPTIVE TRANSMISSION CHANNEL ALLOCATION METHOD AND SYSTEM FOR ISM AND UNLICENSED FREQUENCY BANDS**

Express Mail Label #EL628639744US

PATENT
944-001.040

# ADAPTIVE TRANSMISSION CHANNEL ALLOCATION METHOD AND SYSTEM FOR ISM AND UNLICENSED FREQUENCY BANDS

## Cross-Reference to Related Application

Reference is made to Application Serial No. 09/610,758, entitled "Adaptive Transmission Channel Allocation Method and System for ISM and Unlicensed Frequency Bands" (Attorney Docket No. 944-001.029) by Mauri Honkanen, Antti Lappeteläinen and Arto Palin, assigned to the assignee of this application and filed on July 6, 2000.

## Field of the Invention

The present invention relates generally to a so-called Bluetooth communications system operating at radio frequencies around 2.45GHz and, more particularly, to the allocation of an adaptive transmission channel in a piconet operating in the Bluetooth radio frequency band.

## Background of the Invention

A Bluetooth system provides a communication channel between two electronic devices via a short-range radio link. In particular, the Bluetooth system operates in the radio frequency range around 2.45GHz in the unlicensed Industrial-Scientific-Medical (ISM) band. The Bluetooth radio link is intended to be a cable replacement between portable and/or fixed electronic devices. The portable devices include mobile phones, communicators, audio headsets, laptop computers, other GEOS-based or palm OS-based devices and devices with different operating systems.

The Bluetooth operating frequency is globally available, but the permissible bandwidth of the Bluetooth band and the available RF channels may be different from one country to another. Globally, the Bluetooth operating frequency falls within the 2400MHz to 2497MHz range. In the U.S. and in Europe, a band of 83.7MHz bandwidth is available, and the band is divided into 79 RF channels spaced 1 MHz apart. Bluetooth network arrangements can be either point-to-point or point-to-multipoint to provide connection links among a plurality of electronic devices. Two to eight devices can be operatively connected into a piconet, wherein, at a given period, one of the devices serves as the master while the

others are the slaves. Several piconets may form a larger communications network known as a scatternet, with each piconet maintaining its independence. The baseband protocol for a Bluetooth system combines circuit and packet switching. Circuit switching can be either asynchronous or synchronous. Up to three synchronous data (logical) channels, or one synchronous and one asynchronous data channel, can be supported on one physical channel. Each synchronous channel can support a 64 Kb/s transfer rate while an asynchronous channel can transmit up to 721 Kb/s in one direction and 57.6 Kb/s in the opposite direction. If the link is symmetric, the transfer rate in the asynchronous channel can support 432.6 Kb/s. A typical Bluetooth system consists of a radio link, a link control unit and a support unit for link management and host terminal interface functions. The Bluetooth link controller carries out the baseband protocols and other low-level routines. Link layer messages for link set-up and control are defined in the Link Manager Protocol (LMP). In order to overcome the problems of radio noise interference and signal fading, frequency hopping is currently used to make the connections robust.

Currently, each of the 79 RF channels is utilized by a pseudo-random hopping sequence through the Bluetooth bandwidth. The hopping sequence is unique for each piconet and is determined by the Bluetooth device address of the master whose clock is used to determine the phase of the hopping sequence. The channel is divided into time slots of 625μs in length and numbered according to the master clock, wherein each time slot corresponds to an RF hop frequency, and wherein each consecutive hop corresponds to a different RF hop frequency. The nominal hop rate is 1600 hops/s. All Bluetooth devices participating in the piconet are time and hop synchronized to the channel. The slot numbering ranges from 0 to $2^{27}$ -1 and is cyclic with a cycle length of $2^{27}$. In the time slots, master and slave devices can transmit packets. Packets transmitted by the master or the slave device may extend up to five time slots. The RF hop frequency remains fixed for the duration of packet transmission.

The ISM frequency bands can be used by many different devices, which include wireless local area networks (WLANs), microwave ovens, and lighting equipment. The interference caused by these multiple different applications is inherent to almost any device, which is connected to the piconet. Currently, the usage of ISM frequency bands is growing very fast. In order to survive in these frequency bands, new wireless communication systems

must utilize a robust modulation scheme with a certain method of channel allocation. For example, WLAN systems are using a Frequency Hopping Spread Spectrum (FHSS) method, in which transmission takes place only a short time in each channel, and Direct Sequence Spread Spectrum (DSSS) modulation, which overcomes narrow-band interference by spreading. However, in these systems the allocation of channels, or channelization, is organized by using either a carrier sensing (CS) method or a Code Division Multiple Access (CDMA) method. In the CS method, each of the channels which are to be used are measured in order to determine whether a transmission is taking place in that channel. If the channel under measurement does not have an ongoing transmission, then the channel can be used for hopping. The major problem with the carrier sensing method is that the measurement is ineffective for the traffic type that uses a different modulation method. In the CDMA method, while the narrow-band interferer is spread in the receiver, the received noise is actually increased, thereby reducing the noise margin of the system. Optionally, it is also possible to establish virtual traffic channels by using different hopping frequencies. However, this does not avoid the parts of the spectrum where the interference occurs.

It is advantageous and desirable to provide a method and system for making connections between devices operating in the ISM bands by effectively avoiding the parts of the spectrum where channel conditions such as interference and noise levels may adversely affect the channel connection.

## Summary of the Invention

The primary objective of the present invention is to provide a method and system to ensure the backward compatibility of a piconet device, which is capable of operating in the non- frequency-hopping fashion (BT 2.0) in an environment where the frequency-hopping fashion (BT 1.0) is also used. The backward compatibility ensures that a BT 2.0 device is compatible with a BT 1.0 device.

Accordingly, the present invention provides a method for establishing a connection link in a communications network having a master device and a plurality of slave devices, wherein the communications network has a plurality of frequency channels within a radio frequency band for establishing the connection link, and wherein the connection link between

the master device and the slave devices and the connection link among the slave devices are capable of being carried out in a frequency-hopping fashion. The method comprises the steps of:

establishing a non-frequency-hopping connection link between a first slave device and a second slave device if a communication channel for the non-frequency-hopping connection link is available; and

establishing or maintaining the connection link in the frequency-hopping fashion if the communication channel for the non-frequency-hopping connection link is unavailable.

Preferably, the method further comprises the step of measuring channel conditions in at least a portion of the plurality of frequency channels for determining whether the communications channel for the non-frequency-hopping connection link is available.

Preferably, the channel conditions include the carrier power of the channel and the interference and noise levels affecting the non-frequency-hopping connection link. Preferably, the measurement of channel conditions is carried out by the first slave device. However, it is also possible that the measurement of channel conditions be second slave device or the master device.

Preferably, the method also includes the step of sending to the first slave devices a plurality of measurement parameters including measurement time and frequencies to be measured in order for the first slave device to measure the channel conditions based on the measurement parameters.

Preferably, the method also includes the step of providing the master device a measurement report including results of the channel condition measurements.

Preferably, the method further comprises the step of selecting a frequency channel for establishing the non-frequency-hopping connection link based on the measurement results.

Preferably, the method further comprises the step of providing the first and second slave devices a plurality of channel parameters including the selected frequency. The channel parameters also include a modulation rate and a quality of service requirement.

Preferably, whether the communication link for the non-frequency-hopping fashion between the first and second slave devices is available is also determined based on the transmission power of the first and second slave devices.

Upon establishing the non-frequency-hopping connection link with the first and second slave devices, the master device can give up or retain its role as a master device to the first and/or second slave devices.

The present invention also provides a system for adaptive allocation of transmission channels in order to establish a connection link in a communications network having a master device and a plurality of slave devices, wherein the communications network has a plurality of frequency channels within a radio frequency band for establishing the connection link, and wherein the connection link between the master device and the plurality of slave devices and the connection link among the slave devices are capable of being carried out in a frequency-hopping fashion and wherein the adaptive allocation is carried out to establish a non-frequency-hopping connection link between a first slave device and a second slave device. The system comprises:

a first mechanism for determining whether a communication channel for the non frequency hopping connection link is available;

a second mechanism to establish the non-frequency-hopping connection link between the first slave device and the second slave device if the non-frequency-hopping connection link is available; and

a third mechanism to establish or maintain a frequency-hopping connection link between the first slave device and the master device and between the second slave device and the master device if the non frequency hopping connection link is not available.

The present invention will become apparent taken in conjunction with Figures 1a to 16.

Brief Description of the Drawings

Figure 1a is a diagrammatic representation illustrating the establishment procedure of a connection link in a piconet wherein a slave device sends a request to the master device requesting a BT 2.0 connection link with another slave device.

Figure 1b is a diagrammatic representation illustrating that the master device responds to the requesting slave device, asking the slave device to conduct channel condition measurements.

Figure 1c is a diagrammatic representation illustrating that the slave device sends a measurement report to the master device.

Figure 1d is a diagrammatic representation illustrating that the master device sends a plurality of channel parameters to the two slave devices involved in the BT 2.0 connection link.

Figure 1e is a diagrammatic representation illustrating that the involved slave devices acknowledge receipt of the channel parameters.

Figure 1f is a diagrammatic representation illustrating that the master device stops being the master of the involved slave devices and the involved slave devices form a BT 2.0 subnet.

Figure 1g is a diagrammatic representation illustrating another network configuration, wherein the master device serves as the master of the BT 1.0 connection and the BT 2.0 connection.

Figure 1h is a diagrammatic representation illustrating yet anther network configuration in which the remaining piconet and the spun off subnet become independent of each other.

Figure 2 is a frame structure illustrating an exemplary PDU (Protocol Data Unit) for a slave device to request a BT 2.0 connection link with another slave device.

Figure 3 is a frame structure illustrating an exemplary PDU format used as an *LMP_not_accepted* response.

Figure 4 is a frame structure illustrating an exemplary PDU format used as an *LMP_accepted_start* response.

Figure 5 is a frame structure illustrating an exemplary PDU format used as an *LMP_accepted_establish* response.

Figure 6 is a frame structure illustrating an exemplary PDU format used as an *LMP_measurement_report* response.

Figure 7a illustrates a possible signaling sequence in establishing a BT 2.0 connection link.

Figure 7b illustrates another possible signal sequence in establishing a BT 2.0 connection link.

Figures 8a and 8b are flow charts illustrating an exemplary state diagram of a slave device requesting a BT 2.0 connection link with another slave device.

Figures 9a and 9b are flow charts illustrating an exemplary state diagram of a master device responding to a request for establishing a BT 2.0 connection link between two slave devices.

Figure 10 is a diagrammatic representation illustrating the selection of channel measurement frequencies.

Figures 11a and 11b are diagrammatic representations illustrating a hopping sequence example for packets that occupy 5 time slots.

Figures 12a and 12b are diagrammatic representations illustrating a hopping sequence example for packets that occupy 3 time slots.

Figure 13 is a diagrammatic representation illustrating an example of an RSSI dynamic range.

Figure 14 shows an example of channel windowing.

Figure 15a is a diagrammatic representation illustrating the time slots used for transmission wherein the BT 2.0 subnet uses a sniff mode to maintain synchronization with the remaining BT 1.0 piconet.

Figure 15b is a diagrammatic representation illustrating the time slots used for transmission, wherein the master can establish both BT 2.0 and BT 1.0 communication links with the slave devices.

Figure 15c is a diagrammatic representation illustrating the time slots used for transmission wherein some slave devices are spun off to form an independent BT 2.0 subnet and the original master can establish both BT 2.0 and BT 1.0 communication links with the other slave devices.

Figure 16 is a block diagram illustrating a system for the adaptive allocation of transmission channels.

Detailed Description

Figures 1a through 1g are diagrammatic representations illustrating the establishment procedure of a connection link in a piconet **10** having a plurality of devices **M, S1, S2, S3** and

**S4** which are capable of being connected in a frequency-hopping fashion. The frequency-hopping connection links are well known in the art, and such a connection is referred to herein as a BT 1.0 connection link, associated with the Bluetooth Specification Version 1.0 (BT 1.0). As shown, **M** is currently a master device and **S1**, **S2**, **S3** and **S4** are slave devices. The procedure described here is limited to the case where a slave device wishes to establish a connection link with another slave device in a non-frequency-hopping fashion. The non-frequency-hopping fashion is herein referred to as BT 2.0. As shown in Figure 1a, the connection links **102**, **104**, **106** and **108** between the master device **M** and the slave devices **S1**, **S2**, **S3** and **S4** are initially established according to the BT 1.0 fashion. At any time, any one of the slave devices **S1**, **S2**, **S3** and **S4** can send a request to the master device **M** requesting a BT 2.0 link setup with another slave device. For illustrative purposes, in the initialization phase the slave device **S2** is the initiating unit which wishes to set up a BT 2.0 connection link with the slave device **S4**, for example. Alternatively, the master device **M** may initiate the high-speed, or BT 2.0, connection link between slave devices. As shown in Figure 1a, the slave device **S2** sends a request **200** to the master device **M** requesting a BT 2.0 connection link with the slave device **S4**. For example, the request can be sent in the form of an LMP (Link Manager Protocol) PDU, as shown in Figure 2. Upon receiving the request, the master device **M** may respond to the request with three different PDUs, as listed in Table 1.

| **PDU** | **Content** |
|---|---|
| LMP_not_accepted | Reason if known |
| LMP_accepted_start | Start Measuring with parameters |
| LMP_accepted_establish | Link establishment parameters (frequency, MCR, QoS) |

**TABLE 1. Master-Slave LMP PDUs**

Accordingly, the master may send:

a) an *LMP_not_accepted* PDU (see Figure 3), if the master is unable to support this non- frequency-hopping connection link; or

b) an *LMP_accepted_start* PDU (see Figure 4) or an *LMP_accepted_establish* PDU (see Figure 5), if the master is able to support this frequency-hopping connection link.

If the master device **M** responds with an *LMP_accepted_start* PDU **202**, as shown in Figure 1b, the master device provides a plurality of measurement parameters to the requesting slave device **S2** for channel condition measurements. The *LMP_accepted_start* PDU **202** contains, for example, the measurement time and frequencies to be measured. For the purpose of a direct BT 2.0 slave-to-slave connection link, the interference and noise levels I+N (denoted as "I" hereafter) measurement is carried out during a master-to-slave time slot, and an appropriate frequency offset between the master-to-slave frequency channel and the frequency to be measured has to be used. However, the carrier power C is measured during a slave-to-master time slot, without frequency offset, during the transmission of the other candidate slave device, **S4**. The C level is determined by the Received Signal Strength Indication (RSSI) functionality of the receiver, which, in this case, is the master device **M**. The frequency offset is described below in conjunction with Figures 10 through 12b in more detail. After the scanning time as defined by the master device **M** is over, the slave device **S2** conveys a measurement report **204** to the master device **M**, as shown in Figure 1c. For example, the slave device **S2** returns the measurement results in an *LMP_measurement_report* PDU, as shown in Figure 6. Preferably, the master device starts DH1 (DH=Data High Rate, an Asynchronous Connectionless Link data packet type) communication with the other candidate slave device **S4** in order for S4 to obtain RSSI measurement from the transmitting slave device **S2**. The measurement result will be reported by **S4** in a PDU similar to the *LMP_measurement_report* PDU, as shown in Figure 6.

It should be noted that it is also possible for the master device **M** to conduct channel measurements. In that case, the procedural steps, as described in Figures 1b and 1c, can be omitted.

Based on the I measurement results, the master device **M** selects a non-frequency-hopping channel for the BT 2.0 connection link. The master device **M** must know the

transmission power of the slave device that is transmitting. If power control is not used for power adjustment, the master device **M** can inherently obtain **Tx** from the device class of the transmitting slave device, within the **Tx** error margin. If power control is used, the master device can send a power down command or a power up command to the transmitting slave device to obtain, respectively, the minimum or maximum **Tx** power. The minimum and maximum Tx powers can be obtained by referring to the BT 2.0 specification. Preferably, prior to the measurements, the master device **M** transmits the "increase Tx power" commands to the slave device **S2** to make sure that the slave device **S2** uses the maximum transmission power.

The C measurement results are used for estimating the feasibility of the direct slave-to-slave communication between **S2** and **S4**. From the average C measurement results and the transmission power **Tx** of the slave device **S2**, the master device **M** can obtain an estimate of the path loss between **S2** and **S4**. Similarly, the master device **M** transmits packets to the slave device **S4** and obtains the transmit power of **S4**.

After selecting the non-frequency-hopping channel for the BT 2.0 link, the master device **M** sends the channel parameters in an *LMP_accepted_establish* PDU **206** (see Figure 5) to the slave device **S2**, as shown in Figure 1d. The master device **M** also sends the channel parameters in a similar PDU **207** (not shown) to the slave device **S4**. Subsequently, the slave device **S2** acknowledges receipt of the *LMP_accepted_establish* PDU **206** with an ACK signal **208**, and the slave device **S4** acknowledges receipt of the PDU **207** with an ACK signal **209**, as shown in Figure 1e. At this point, the master device **M** starts a BT 2.0 transmission by sending certain data frames to **S2** and **S4** at fixed intervals until both the slave devices **S2** and **S4** acknowledge receipt of the respective frames. Finally, the master device **M** delegates **S2** (or **S4**) to be a BT 2.0 master of a new subnet **20** by converting the slave devices **S2** and **S4** into a temporary BT 2.0 master **HM** and a BT 2.0 terminal **T1,** respectively, as shown in Figure 1f. The BT 2.0 communication link is denoted by reference numeral **214**. The BT 1.0 communication link between the master device **M** and the other slave devices **S1, S3** remains unchanged. The remaining BT 1.0 piconet is denoted by reference numeral **10'**.

The BT 2.0 subnet **20** maintains synchronization with the remaining BT 1.0 piconet

**10'** by periodically listening to traffic in the BT 1.0 piconet **10'** or using a SNIFF mode, as shown in Figure 15a. As described, the backward compatibility of the slave device **S2** and the slave device **S4** makes it possible for these devices to operate in either the BT 2.0 mode or BT 1.0 mode.

The backward compatibility of a BT 1.0 piconet allows the same piconet to operate fully or partially in the BT 2.0 communication link. In order for the devices in the same piconet to operate in the BT 2.0 fashion, the master device must be capable of communicating in the BT 2.0 fashion or, at least, it must understand Link Manager Protocol (LMP) messages sent by the requesting slave device (in this case, **S2**) in the BT 1.0 mode in order to set up the BT 2.0 mode. Any unit in the piconet can request a BT 2.0 connection, but the procedure to set up the BT 2.0 communication link is always coordinated and executed by the master device of the piconet. The new BT 2.0 subnet formed by the involved slave devices can maintain synchronization with the original BT 1.0 piconet. However, the new BT 2.0 subnet can also be spun off from the original BT 1.0 piconet **10** to become an independent piconet **20**, without any synchronization to the remaining BT 1.0 piconet **10'**.

There are basically two possibilities for maintaining synchronization after the involved slave devices operate in the BT 2.0 fashion:

- The original master device plays a dual role in the piconet **10"**, as shown in Figure 1g. It can maintain a BT 1.0 connection link with some slave devices (**S1, S3**) and, at the same time, establish a BT 2.0 connection link with other slave devices (**T1, T2**), as shown in Figure 1g. The BT 2.0 connection links are denoted by reference numerals **210** and **212**. The time slots for transmission, in this situation, are shown in Figure 15b.

- One of the involved slave devices is assigned by the original master device to become a temporary master (HM) of the BT 2.0 subnet, and the master device only provides BT 1.0 connection links with other slave devices (**S1, S3**) in the remaining piconet, as shown in Figure 1f.

Alternatively, one of the involved slave devices is assigned to become a temporary master (HM1) of a separate BT 2.0 subnet, while the original master device can establish both BT 1.0 and BT 2.0 connection link with the remaining slave device (**S1, S3, T3**), as shown in

Figure 1h. In this case, the BT 2.0 subnet **20** and the piconet **10'** are independent, without synchronization therebetween. In Figure 1h, the master of the spun-off BT 2.0 is denoted by **HM1**, while the original master device plays the role of a BT 1.0 master (**M**) and the role of a BT 2.0 master (**HM0**) in the remaining piconet **10'**. The time slots for transmission, in this situation, are shown in Figure 15c.

It is likely that the channel conditions regarding carrier power C and/or interference and noise conditions (I) change during the data transfer between terminals **HM** and **T1** (Figure 1f). Thus, the selected frequency used for the current non-hopping channel may no longer be the best frequency for data transmission in the BT 2.0 connection link. To monitor the change in channel conditions, terminals **HM** and **T1** can be adapted to monitor propagation characteristics and data flow quality in the used frequency channel. For example, the monitoring may include continuous averaging of RSSI, transmission power, average packet error rate, average bit error rate, used modulation/coding and data packet memory monitoring. These values are compared to radio quality of service (QoS) parameters, which are used as thresholds. If a threshold is not met, another frequency is selected for the new non-hopping channel. In general, among the BT 2.0 terminals (**HM** and **T1** in this illustrative example) some are empowered to make a decision regarding the frequency to be used in the new BT 2.0 connection link while some are not. Thus, the non-decision-making terminals must report the threshold failure to the empowered terminals. In particular, a specific PDU, *LMP_radioQoS_failure*, can be used to report the threshold failure. This PDU may indicate which radio QoS criterion or criteria are not met and the current RSSI value, packet error rate, etc. The PDU can be used to report:

a) whether the mean RSSI is above or below a certain threshold;

b) whether the packet error rate exceeds a certain threshold;

c) whether the transmission power exceeds a certain threshold; and

d) whether the used modulation/code belongs to a feasible set of modulation/coding schemes.

When it is required to use another frequency for maintaining the BT 2.0 connection link, the terminal empowered to make the decision regarding the frequency to be used in BT 2.0 connection links has three options:

1) it may decide to stay on the selected frequency that is currently used for the BT 2.0 connection link, and use link adaptation and/or power control to improve the data flow quality. If transmissions are not continuous but repeated periodically, re-timing may be considered;

2) it may start a new measurement process in order to select a new frequency for the new non-hopping channel; or

3) it may allocate a new frequency for the new non-hopping channel based on the previous channel measurement results. For example, it could pick the second best frequency in terms of low interference and noise level in the previous channel measurement results (take Figure 14, for example, where $f_2$ is the best frequency and $f_1$ is the second best frequency).

Selection of the proper action in terms of the above alternatives may include two phases. In the first phase, it is determined whether degradation in the radio QoS is caused by insufficient RSSI or due to interference. This can be carried out by comparing RSSI values, packet error rates and used modulation/coding methods. If the cause is interference (i.e., RSSI is sufficient for the used modulation/coding but packet error is high), then a new channel measurement process or a new frequency allocation based on the previous measurement can be carried out. If the cause is insufficient RSSI, then Option 1, as described above, should be selected. The second phase is necessary only if the interference is the cause for the radio QoS degradation. In the second phase, Option 2 should be selected if the involved devices are non-delay sensitive, while Option 3 should be selected if the involved devices are delay sensitive.

Figures 2 to 6 are examples of LMP PDU formats. Figure 2 represents a bit level description of *LMP_BT2.0_req* PDU prior to cyclic redundancy check (CRC) and encoding. As shown in Figure 2, Opcode **56** in the payload area is used to indicate that the requested connection link is in accordance with the BT 2.0 fashion.

As shown in Figure 3, the *LMP_not_accepted* PDU contains the Opcode **56** in the payload area to indicate that the response is related to the requested BT 2.0 connection link. The payload area may contain a reason why the master is unable to support the BT 2.0 link (*Unsupport_LMP_feature*).

As shown in Figure 4, the *LMP_accepted_start* PDU contains the Opcode **56** in the

payload area to indicate that the response is related to the requested BT 2.0 connection link. The payload area also contains measurement parameters for channel measurements. As shown in Figure 4, the measurement parameters include the scanning time for the slave device to measure the channel conditions at each channel (*Measurement_time*).

As shown in Figure 5, the *LMP_accepted_establish* PDU may include link establishment parameters such as the frequency (*Used_frequency*) to be used for the BT 2.0 connection link, Modular Code Rate (MCR) and QoS parameters. The QoS parameter set also includes radio QoS parameter thresholds. The QoS parameters may include *min_mean_RSSI, max_mean_RSSI, max_packet_error_rate, max_Tx_power, min_Tx_power, and set_of_feasible_modulation/coding rates.*

As shown in Figure 6, the *LMP_measurement_report* PDU may include the measured carrier power C value (*C_Value*) and the interference and noise I levels (*I_Value*) in a plurality of measured channels (*Measurement_freq*).

In the course of establishing a BT 2.0 connection link at the request of the slave device, the possible signaling sequences between a requesting slave device and the master device are shown in Figures 7a and 7b. In Figure 7a, originally the two involved slave devices (**S2, S4** in Figures 1a-1e) are linked to the master device according to the BT 1.0 fashion, as denoted by numeral **100**. In the initialization phase, the requesting slave sends an *LMP_BT2.0_ req* PDU **200** to the master device, requesting the establishment of a BT 2.0 link. If the master is unable to support the BT 2.0 link for any reason, it responds to the request by sending an *LMP_not_accepted* PDU **201** to the requesting slave, stating the reason for not supporting the BT 2.0 link. For example, the reason for not supporting the BT 2.0 link may include that the data flow quality is currently below the radio QoS requirements. It is possible that the master device finds that the other involved slave device (**S4**) is not in compliance with BT 2.0 requirements. Accordingly, the BT 1.0 link between the two involved slave devices and the master device is maintained, as denoted by numeral **100'**. It is possible that when the master device does not know anything about the BT 2.0 connection link and fails to respond to the request **200**, the requesting slave device should not wait indefinitely for a response from the master device but maintain the BT 1.0 connection link after a set waiting period (see Figure 8a, step **317**). At a later time, the requesting slave

device sends another *LMP_BT2.0_ req* PDU **200'** to the master device, again requesting the establishment of a BT 2.0 link. If the master is able to support the BT 2.0 link and it has selected a frequency for the BT 2.0 link, it responds to the request by sending an *LMP_accepted_establish* PDU **206** to the requesting slave device, including the selected frequency, MCR and the required QoS parameters. It is understood that the master device also sned a similar PDU to the other involved slave device. Subsequently, a BT 2.0 link is established between the requesting slave and the other slave device, as indicated by numeral **220**. However, the master must give up its master role with regard to the two involved slave devices, as shown in Figure 1f.

Another possible signal sequence is shown in Figure 7b. As shown in Figure 7b, upon receiving a request **200"** from the requesting slave device requesting the establishment of a BT 2.0 link, the master device sends the requesting slave device an *LMP_accepted_start* PDU **202** including the frequencies to be measured in order to establish a non-frequency-hopping link. The slave device measures the carrier power C and/or the interference and noise conditions I as indicated by numeral **190** and reports to the master the measurement results in an *LMP_measurement_report* PDU **204**. Based on the measurement results, the master selects a frequency for the BT 2.0 link. The master sends an *LMP_accepted_establish* PDU **206'** to the requesting slave device, including the selected frequency, MCR and the required QoS parameters. Subsequently, a BT 2.0 link is established between the two involved slave devices as indicated by numeral **220'**. Because LMP PDUs are sent over an asynchronous connection-less (ACL) link, all packets are acknowledged in the Link Control level. Hence, a separate acknowledge signal ACK in the Link Management level is not required.

Figures 8a and 8b are flow charts illustrating a sequence of steps executed by a requesting slave device. As shown in Figure 8a, initially both the slave devices are connected with a master device in a BT 1.0 fashion, as indicated by numeral **310**. As the requesting slave device wishes to establish a BT 2.0 link with the other involved slave device, it starts out by initializing a BT 2.0 link setup message from its upper layer at step **312** and sends an *LMP_BT2.0_req* PDU to the master device at step **314**. It waits for a response from the master at step **316**. It is possible that the master device fails to respond to the request for a

certain reason, and the requesting slave device will not receive a response from the master. Preferably, the requesting slave device sets a time limit for receiving such a response. As shown at step **317**, if the requesting slave device does not receive the response from the master device after the set time has expired, it indicates the request failure to the upper level at step **320**. If the set time has not expired, the slave device keeps waiting until it receives a response at step **318**. There are three possibilities regarding the response from the master device: a) the response is an *LMP_not_accepted PDU*; b) the response is an *LMP_accepted_establish* PDU; or c) the response is an *LMP_accepted_start* PDU. If possibility (a) occurs, the slave device indicates the request failure to the upper level at step **320**. The BT 1.0 link between the two slave devices and the master is maintained or re-established, as indicated by numeral **322**. If possibility (b) occurs, the requesting slave device establishes the BT 2.0 connection link with the other involved slave device according to the frequency selected by the master device at step **324** and indicates the BT 2.0 connection link to the upper layer at step **326**. The BT 2.0 link between the two involved slave devices is maintained as long as it is required, as indicated by numeral **328**. If possibility (c) occurs, the slave device carries out the channel measurement procedure, as shown in Figure 8b.

As shown in Figure 8b, the slave device measures channel conditions at step **330** and sends measurement results to the master channel at step **332**. The slave device must wait for a response from the master device at step **334** in order to take the next course of action. There are two possibilities regarding the response from the master device: a) the response is an *LMP_not_accepted PDU*; or b) the response is an *LMP_accepted_establish* PDU. If possibility (a) occurs, the slave device indicates the request failure to the upper level at step **340**. The BT 1.0 link between the slave devices and the master is maintained or re-established, as indicated by numeral **342**. If possibility (b) occurs, the requesting slave device establishes the BT 2.0 connection link with the other involved slave device according to the frequency selected by the master device at step **344** and indicates the BT 2.0 connection link to the upper layer at step **346**. The BT 2.0 link between the two involved slave devices is maintained as long as it is feasible, as indicated by numeral **348**.

Figures 9a and 9b are flow charts illustrating a sequence of steps executed by a master

device. As shown in Figure 9a, initially the master device is connected with the involved slave devices in a BT 1.0 fashion, as indicated by numeral **360**. Upon receiving an *LMP_BT2.0_req* PDU from a slave channel requesting to establish a BT 2.0 connection link at step **362**, the master device determines whether it can support the BT 2.0 connection link and how to respond to the requesting slave device at step **364**. There are three possibilities regarding the response to be sent to the requesting slave device at step **366**: a) the response is an *LMP_not_accepted PDU* indicating that the master device is unable to support a BT 2.0 connection link, at least for the time being; b) the response is an *LMP_accepted_establish* PDU; and c) the response is an *LMP_accepted_start* PDU. If possibility (a) occurs, the BT 1.0 link between the slave and the master is maintained or re-established, as indicated by numeral **368**. If possibility (b) occurs, the master device provides link establishment parameters to the requesting slave device and the other involved slave device at step **370** and indicates the BT 2.0 connection link to the upper layer at step **372**. The BT 2.0 link between the two involved slave devices is maintained as long as it is feasible, as indicated by numeral **374**. If possibility (c) occurs, the master device provides the requesting slave device with measurement parameters for carrying out the channel measurement procedure, and the process continues in Figure 9b.

As shown in Figure 9b, after sending out the *LMP_accepted_start* PDU to the requesting slave channel, the master device waits for the measurement results, as contained in an *LMP_measurement_report* PDU from the requesting slave device, at step **380**. Based on the measurement results, the master must decide the next course of action at step **382**. There are two possibilities regarding the decision made by the master device at step **384**: a) the master sends an *LMP_not_accepted PDU* to the slave device to indicate that it is unable to support the requested BT 2.0 connection link, based on the channel conditions measured by the requesting slave device; or b) the master sends an *LMP_accepted_establish* PDU to provide link establishment parameters to the requesting slave device, and a similar PDU to the other involved slave device. If possibility (a) occurs, the BT 1.0 link between the slave devices and the master is maintained or re-established, as indicated by numeral **386**. If possibility (b) occurs, the BT 2.0 connection link between the two involved slave devices is

established at step **388** and the upper level is notified of the BT 2.0 connection link at step **390**. The BT 2.0 link between two involved slave devices is maintained as long as it is feasible, as indicated by numeral **392**.

It should be noted that Figures 8a through 9b illustrate the flow charts involving a slave device and a master device when the establishment of the BT 2.0 connection link between two slave devices is requested by one of the slave devices. In a similar manner, the master device can initiate a BT 2.0 connection link between any two slave devices in the piconet.

As described in conjunction with Figure 1b, when the requesting slave device **S2** carries out the I measurement, it avoids measuring the master-to-slave transmission itself and/or its spectral leakage. Accordingly, an appropriate frequency offset between the master-to-slave frequency channel and the frequency to be measured is used. Preferably, the frequency offset value is high enough so that the transmitted power leakage over the adjacent channels does not significantly affect the measurement results. The exemplary channel measurement frequencies are shown in Figure 10. It should be noted that the illustration and the description taken in conjunction with Figure 10 through Figure 12b are for the BT 2.0 connection between the master device and a slave device, where the I measurement is carried out during a slave-to-master time slot and the C measurement is carried out during a master-to-slave time slot, in contrast to the direct slave-to-slave connection of the present invention, wherein the I measurement is carried out during a master-to-slave slot and the C measurement is carried out during a slave-to-master time slot. However, the method of shifting channel frequences and designating a hopping sequence for multi-slot packet transmission, as illustrated in Figures 10 – 12b, can be applied to the direct slave-to-slave BT 2.0 connection, according to the present invention.

As shown in Figure 10, the odd-numbered time slots are master-to-slave slots in which the carrier power C measurements are made, and the even-numbered time slots are slave-to-master slots in which the interference and noise I levels are measured. It should be noted that the channel that is used for I measurement in each slave-to-master slot is offset by 4 channels from the slave-to-master frequency in the current hopping sequence. Figure 10 illustrates a possible way to select the I measurement frequency during a slave-to-master slot

for packet transmission over one-slot frames.

In multi-slot packet transmission, a special offset calculation is used to prevent measuring slave-to-master slots as an I measurement channel. Figures 11a and 11b illustrate a hopping sequence for packets that occupy 5 time slots. In Figure 11a, the frequency of the master-to-slave slots is $f_1$, while the frequency of the slave-to-master slot is $f_6$. It is possible, for example, to use $f_b = f_6 \pm 4$ as the measurement frequency, which is different from both $f_6$ and $f_1$. Likewise, in Figure 11b, the frequency of the master-to-slave slot is $f_1$ while the frequency of the slave-to-master slots is $f_2$. It is possible, for example, to use $f_b = f_2 \pm 4$ as the measurement frequency, which is different from both $f_2$ and $f_1$.

Figures 12a and 12b illustrate a hopping sequence for packets that occupy 3 time slots. In Figure 12a, the frequency of the first master-to-slave slots is $f_1$, while the frequency of the subsequent slave-to-master slot is $f_4$. It is possible, for example, to use $f_b = f_4 \pm 4$ as the measurement frequency, which is different from both $f_4$ and $f_1$. Likewise, in Figure 12b, the frequency of the first master-to-slave slot is $f_1$, while the frequency of the subsequent slave-to-master slots is $f_2$. It is possible, for example, to use $f_b = f_2 \pm 4$ as the measurement frequency, which is different from both $f_2$ and $f_1$. However, the situation can be more complex. Let $f_a$ be the first possible frequency of a multi-slot packet and $f_c$ be the current hopping frequency, and the frequency of the I measurement channel be $f_b$, which is 10MHz from the current hopping frequency. The 10MHz frequency offset is to ensure that the image frequency of the receiver does not coincide with the actual frequency, because the limited rejection at the image frequency may affect the measurement results.

Within the 79 available frequency channels of the ISM band, if $10<|f_b - f_a|<69$, then we can use $f_b = f_c + 10$. Otherwise, the possible value for $f_b$ is determined from the following equation:

$$f_b = g(f_c, f_a, f_b)$$

where

$$g(f_c, f_a, f_b) = (f_c - 10) - 79\lfloor (f_c - 10)/79 \rfloor, \forall i[|f_{bi} - f_{ai}|<10 \vee |f_{bi} - f_{ai}|>69]$$

As described earlier, the preferred measurement resolution is 1MHz. After the

channel measurements are completed, there are 79 C values and 79 I values, with one C and one I value for each frequency channel. These values are normally averaged over a certain amount of measured C and I values, because the same channel might be measured a number of times. The averaging of the measurement results can be carried out during the measurement (continuous averaging) or after the measurement. The averaging procedure for the C value is shown below:

$$C_{f79}\,(ave) = (1/N)\sum_{k=N}^{N-1} C_{f79}\,(k),$$

where N is the number of measurements and the averaging is carried out over each of the 79 channels. If the averaging is carried out over the whole band, then

$$C_f(ave) = (1/79)\sum_{I=0}^{79} \{(1/N)\sum_{k=0}^{N-1} C_{fi}(k)\},$$

where N is the number of measurements on each of the 79 channels.

The I measurement results are averaged in a similar way. However, averaging over the whole band is not used. Averaging of the carrier power C over the whole band means that the selection of a best channel placement is based on the I measurement only. In this case C measurements are not required. This approach ignores fast fading, which is actually desirable. Notches caused by fast fading are changing their locations quite swiftly if there are even slight changes in the propagation environment, and, therefore, their locations should not be relied upon when the optimum channel placement is considered. Alternatively, it is possible to measure the I conditions, because they probably give satisfactory results in a channel placement.

As a typical procedure, a number of measured C and I values from the same channels are parameterized, as this amount depends on the available measurement time and the connection initialization time requirements. For example, if it is required to make 10 measurements per channel, then the required time for measurement is given by

10x79x0.001250s = 0.98s. The accuracy of the measured C and I values is dependent on the receiver RSSI measurement accuracy. An example of a 64dB dynamic range of an RSSI measurement is illustrated in Figure 13.

Depending on the RSSI measurement resolution, the required amount of bits needed to present C and I values can be estimated. For example, if there is a 3dB resolution, the whole dynamic range of the RSSI measurement can be divided into 22 levels. Thus, a minimum of 5 bits is used so that all the levels can be presented. With the measured I values, it is possible to use only 4 bits of data because the I values above a certain level may not be worthy of being addressed. At those high levels, the interfering source may be too strong and make the C/I ratio too small for channel selection regardless of what the C value would normally be. The possible values for C and I measurement are given in Table 2.

| RSSI Level | Possible bit vector for C (5 bits) | Possible bit Vector for I (4 bits) |
|---|---|---|
| -20 | 00000 | |
| -23 | 00001 | |
| -26 | 00010 | |
| -29 | 00011 | |
| -32 | 00100 | |
| -35 | 00101 | |
| -38 | 00110 | 0000 |
| -41 | 00111 | 0001 |
| -44 | 01000 | 0010 |
| -47 | 01001 | 0011 |
| -50 | 01010 | 0100 |
| -53 | 01011 | 0101 |
| -56 | 01100 | 0110 |
| -59 | 01101 | 0111 |
| -62 | 01110 | 1000 |
| -65 | 01111 | 1001 |
| -68 | 10000 | 1010 |
| -71 | 10001 | 1011 |
| -74 | 10010 | 1100 |
| -77 | 10011 | 1101 |
| -80 | 10100 | 1110 |
| -83 | 10101 | 1111 |

**TABLE 2. Possible C and I Bit Vectors**

Accordingly, the needed data packet size would be 9x79=711 bits. This packet size indicates that a DM3/DH3 ACL packet type is required (DM=Data Medium Rate). However, it is possible to organize measurement data such that one-slot packet types can be used in transmission. In practice, this signifies a data packet of 136-216 bits (DM1/DH1). In this case, the measurement data has to be sorted, for example, so that only the 9-12 lowest I values and the corresponding C values are reported, instead of all the measured C and I values. It should be noted that when the C and I information is assigned only to certain frequency channels, the associated frequency information must also be notified along with the reported C and I values. The 79 frequencies in the ISM need 7 bits of data to notify. An example of data packet format prior to data whitening and coding is illustrated in the *LMP_measurement_report* PDU, as shown in Figure 6.

A DH1 packet can contain up to 12 measured units including C, I and frequency values because no coding is utilized. A DM1 packet contains only 9 measured units because 2/3 coding is used. A summary of the reporting format is shown in Table 3. This reporting format can be defined by the master device with the *LMP_accepted_start* PDU.

| **Reporting format** | **Needed amount of bits** | **Needed payload type** |
|---|---|---|
| Full measurement | 9 x 79 = 711 | DM3/DH3 |
| 1 only reporting | 4 x 79 = 316 | DM3/DH3 |
| 12 best channels | (9 + 7) x 12 = 192 | DM1/DH1 |

**TABLE 3. Required Reporting Payload Types**

The measurement results can be further processed by channel windowing so that it is possible to take into account the BT 2.0 channel width, which might differ from the channel measurement resolution. The window for channel windowing can be, for example, a slide average window, which is originally slid through the measurement data of 1MHz resolution. The width of the sliding window can be, for example, the same as the channel bandwidth of the BT 2.0 channels. An example of channel windowing, which is used in channel

measurements, is shown in Figure 14. It is also possible to utilize different weighting for adjacent channels or the whole set of channels, if so desired. Because of channel selection filtering, interference in adjacent channels is usually not as significant as interference in the channels that are in use. In Figure 14, the I value as processed by channel windowing is denoted by

$$s_i = \sum_{k=0}^{N-1} I_{f(i+k)}$$

where N is the number of frequency channels over which channel windowing is carried out. With N=4, $s_2$ is the channel-windowing average value of I over $f_2$, $f_3$, $f_4$ and $f_5$, for example. As shown in Figure 14, $s_0$ has the lowest level of interference. Thus, any one of the channels $f_0$, $f_1$, $f_2$, and $f_3$ can be used for BT 2.0 transmission because $s_0$ is the sum of interference in those channels. For that reason, the sum of interference after channel 76 is not available.

Figure 15a shows the time slots for transmission with regard to a synchronized BT 2.0 subnet, wherein one of the slave devices is the assigned temporary master. In Figure 15a, PM denotes the master-to-slave time slot in the BT 1.0 mode, S1 and S3 denotes the slave-to-master time slots designated for the respective slave devices in the BT 1.0 mode. HV3 denotes a High quality Voice packet type usually used for voice transmission. HM is the temporary master in the BT 2.0 subnet, and HR represents the high rate mode specified by the BT 2.0 mode. With the SNIFF mode, the HM sniffs on specified time slots for its message, rather than listening on every slot of the message for HM originated from the original master.

Figure 15b shows the time slots for transmission with regard to a piconet, wherein the master can establish both the BT 2.0 and BT 1.0 connection links with the slave devices. In Figure 15b, S1 and S3 denotes the slave-to-master time slots for the respective slave devices connected in the BT 1.0 fashion, and T1 and T2 denotes the time slots regarding the BT 2.0 connection link.

Figure 15c shows the network configuration with regard to a spun-off BT 2.0 subnet and the remaining piconet, as shown in Figure 1h. The master of the spun off BT 2.0 is denoted by HM1 and the original master device is denoted by HM0. The packet types for the

piconet is of an Asynchronous Connection-Less (ACL) link.

Figure 16 is a block diagram illustrating a system **20** for the allocation of adaption transmission channels. As shown in Figure 16, the system **20** includes a plurality of mechanisms included in the electronic devices in a piconet. In particular, a slave device **30** includes a requesting mechanism **32** for sending a request **200** (see Figure 1a) to a master device **40**, requesting the establishment of a BT 2.0 connection link. The master device includes a deciding mechanism **42** for determining whether it is able to support a BT 2.0 connection link, at least at the time of request. The slave device further includes a mechanism **34** for channel measurements, a mechanism **36** for processing the measurement results and reporting the measurement results to the master device. Preferably, the slave device also includes a mechanism **38** to recognize that the master device fails to respond to the request. Both the master device and the slave device also include a mechanism **50** for establishing a BT 2.0 or BT 1.0 connection link. As shown in Figure 16, other messages **230**, such as the response **202** in Figure 1b, and the response **204** in Figure 1c, can also be sent from one device to another.

Although the invention has been described with respect to a preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and various other changes, omissions and deviations in the form and detail thereof may be made without departing from the spirit and scope of this invention.

What is claimed is:

1. A method of establishing a connection link in a communications network including a master device and a plurality of slave devices, wherein the communications network has a plurality of frequency channels within a radio frequency band for establishing the connection link, and wherein the connection link between the master device and the slave devices and the connection link among the slave devices are capable of being carried out in a frequency-hopping fashion, said method comprising the steps of:

establishing a non-frequency-hopping connection link between a first slave device and a second slave device if a communication channel for said non-frequency-hopping connection link is available; and

establishing or maintaining the connection link in the frequency-hopping fashion if the communication channel for said non-frequency-hopping connection link is unavailable.

2. The method of claim 1, further comprising the step of measuring channel conditions in at least a portion of the plurality of frequency channels for determining whether the communication channel for said non-frequency-hopping connection link is available based on the measured conditions.

3. The method of claim 2, wherein the channel conditions include carrier power of the measured channel and interference and noise levels affecting the non-frequency-hopping connection link.

4. The method of claim 2, wherein the measurement of the channel conditions is carried out by the first slave device.

5. The method of claim 4, further comprising the step of providing the first slave device a plurality of measurement parameters, including measurement time and frequencies to be measured, wherein the first slave device measures the channel conditions based on the measurement parameters.

6. The method of claim 4, further comprising the step of providing the master device a measurement report including results of the channel condition measurements.

7. The method of claim 6, further comprising the step of selecting a frequency for establishing said non-frequency-hopping connection link based on the measurement report.

8. The method of claim 7, further comprising the step of providing the first slave device and the second slave device a plurality of channel parameters including the selected frequency.

9. The method of claim 8, wherein the channel parameters further include a modulation code rate.

10. The method of claim 8, wherein the channel parameters further include a quality of service requirement.

11. The method of claim 3, wherein whether the communication channel for said non-frequency-hopping connection link is available is also determined based on transmission power of the first slave device.

12. The method of claim 3, wherein whether the communication channel for said non-frequency-hopping connection link is available is also determined based on transmission power of the second slave device.

13. The method of claim 1, further comprising the step of the first slave device sending a request to the master device requesting establishment of said non-frequency-hopping connection link.

14. A system for adaptive allocation of transmission channels for establishing a connection link in a non-frequency-hopping fashion within a communications network

including a master device and a plurality of slave devices, wherein the communications network has a plurality of frequency channels within a radio frequency band for establishing the connection link, and wherein the connection link between the master device and the slave devices and the connection link among the slave devices are capable of being carried out in a frequency-hopping fashion, and wherein said adaptive allocation is carried out to establish the non-frequency-hopping connection link between a first slave device and a second slave device, said system comprising:

a first mechanism for determining whether a communication channel for the non-frequency-hopping connection link is available;

a second mechanism for establishing the connection link between the first slave device and the second slave device in the non-frequency hopping fashion if the communication channel for the non-frequency-hopping connection link is available; and

a third mechanism for establishing or maintaining the connection link between the first slave device and the second slave device in the frequency-hopping fashion if the communication channel for the non-frequency-hopping connection link is unavailable.

15. The system of claim 14, wherein the first mechanism determines whether the communication channel for the non-frequency-hopping connection link is available based on channel conditions including carrier power of the frequency channels and interference and noise levels, which may affect the non-frequency-hopping connection link, said system further comprising a fourth mechanism for measuring the channel conditions.

16. The system of claim 15, wherein the channel conditions are measured based on a plurality of measurement parameters including measurement time and frequencies to be measured.

17. The system of claim 15, further comprising means for providing the master device a measurement report including results of the channel condition measurements for allowing the master device to select a frequency for establishing said non-frequency-hopping connection link based on the measurement report.

18. The system of claim 15, wherein the first mechanism determines whether the communication channel for the non-frequency-hopping connection link is available also based on transmission power of the first slave device.

19. The system of claim 15, wherein the first mechanism determines whether the communication channel for the non-frequency-hopping connection link is available also based on transmission power of the second slave device.

Abstract of the Disclosure

A method and system for establishing a non-frequency-hopping connection link between a slave device with another slave device in a communications network having a plurality of frequency channels within a radio frequency band known as the unlicensed ISM band, wherein the connection links between slave devices are capable of being carried out in a frequency-hopping fashion. The non-frequency-hopping connection link can be established after the channel conditions, including the carrier power of the channel and the interference and noise levels adversely affecting the connection link, are measured.

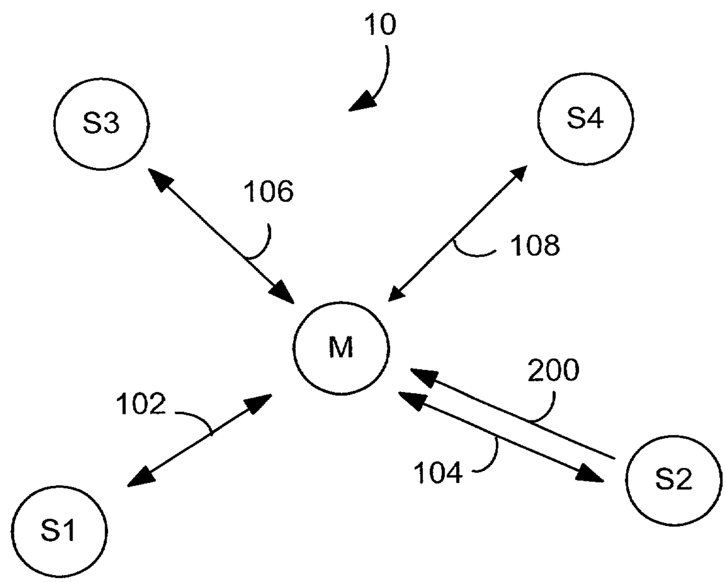



FIG. 1a

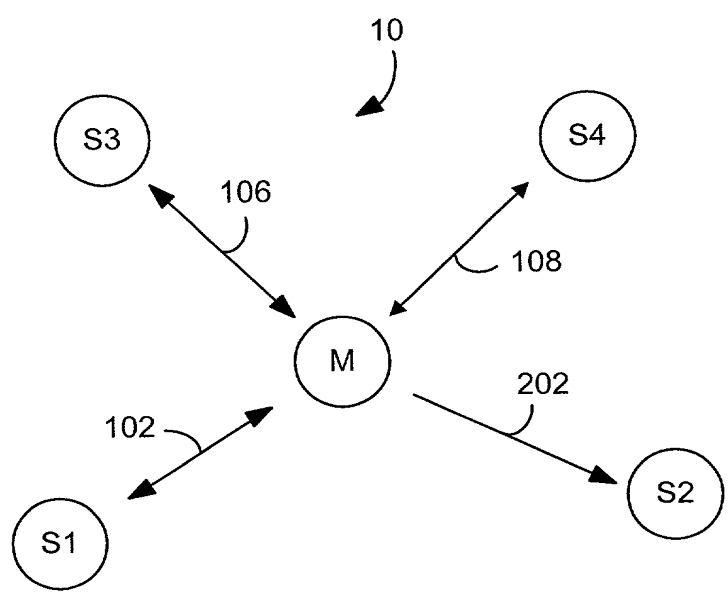



FIG. 1b

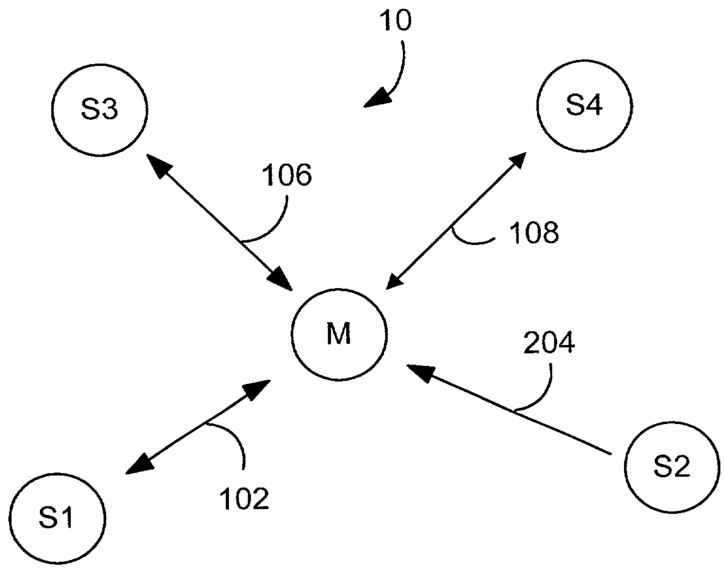



FIG. 1c

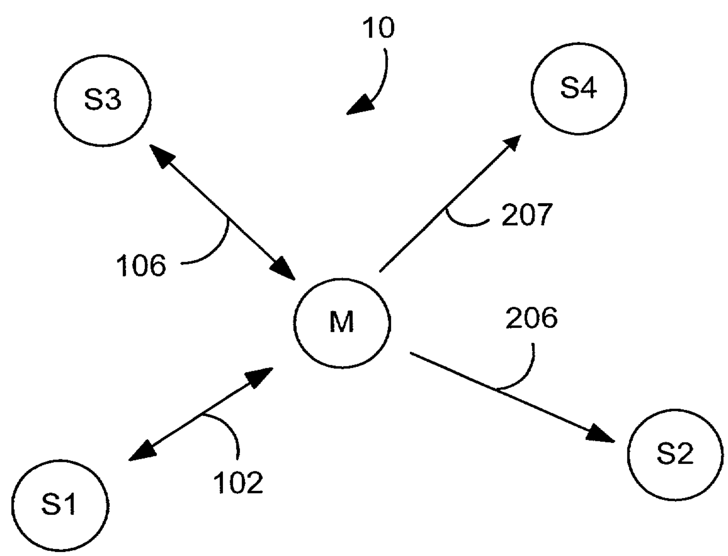



FIG. 1d

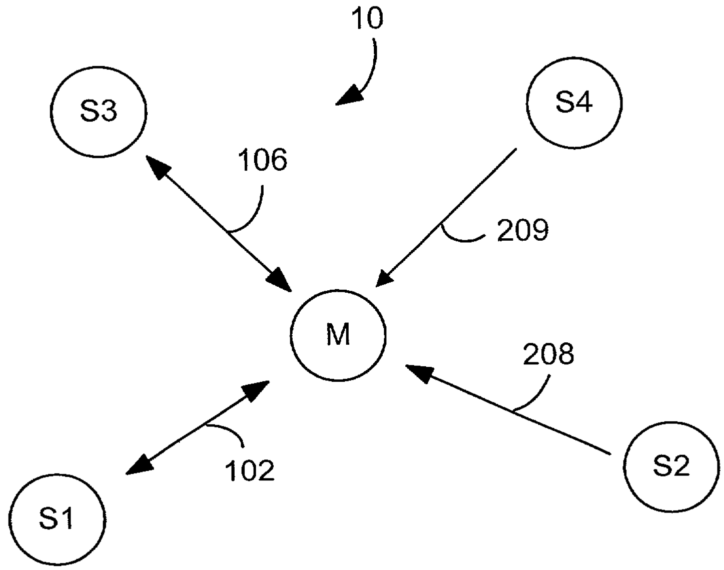



FIG. 1e

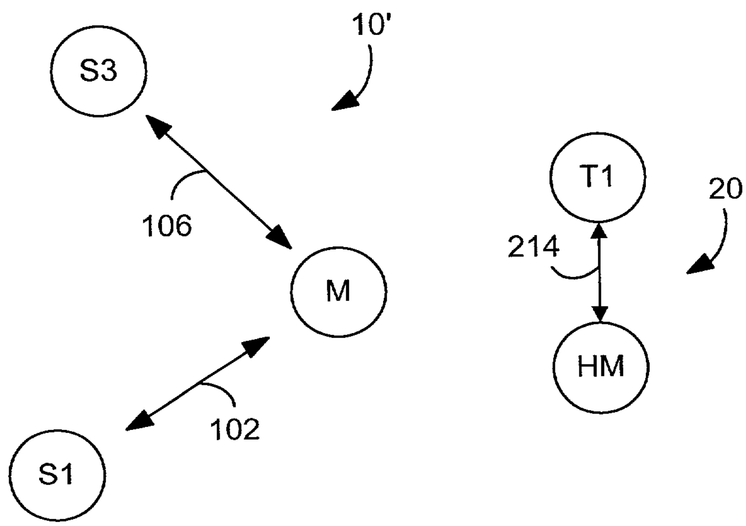



FIG. 1f

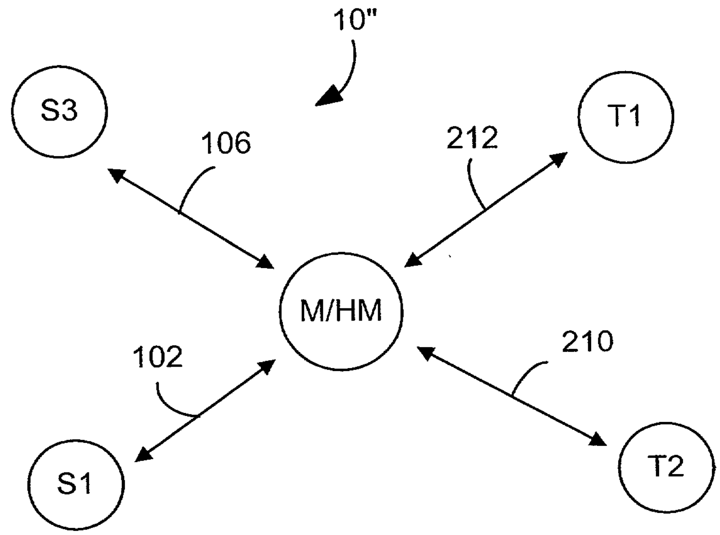

10"
S3
106
212
T1
M/HM
102
210
S1
T2

FIG. 1g

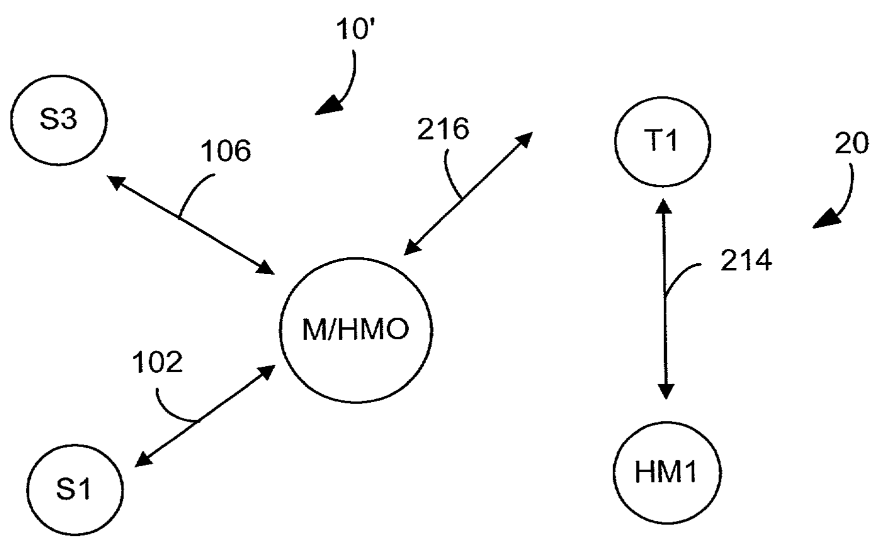
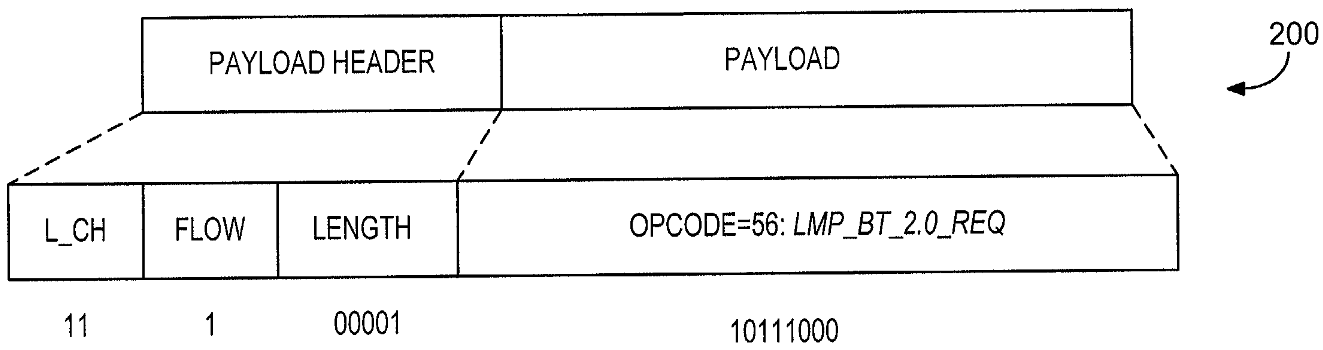
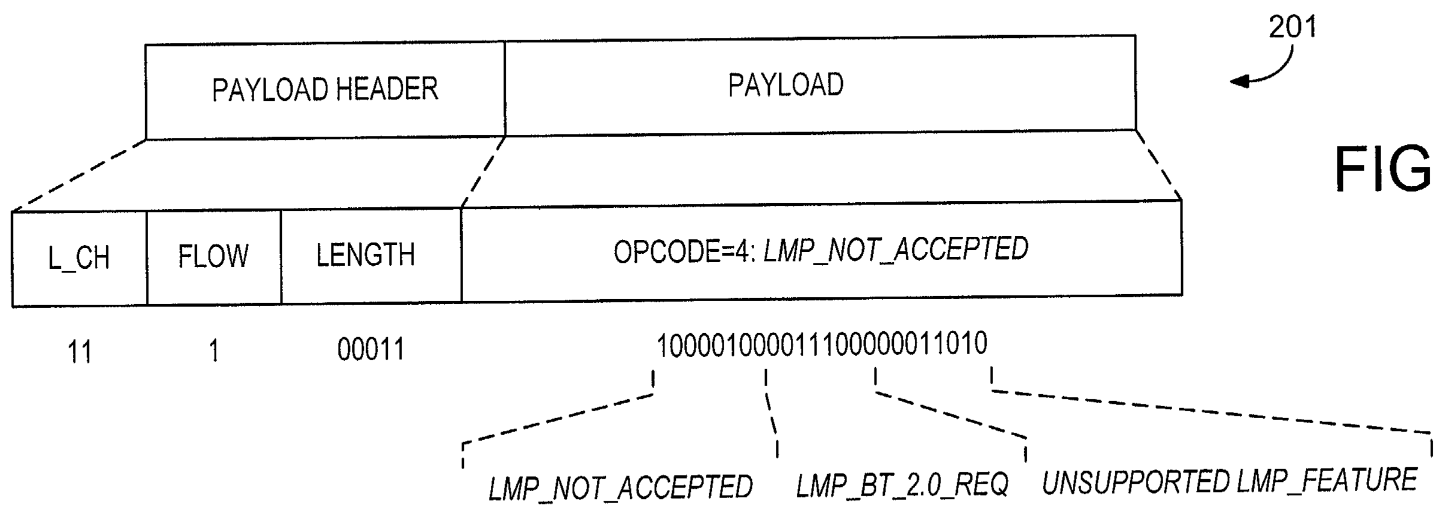

10'
S3
106
216
T1
20
214
M/HMO
102
S1
HM1

FIG. 1h



200
PAYLOAD HEADER
PAYLOAD
L_CH
FLOW
LENGTH
OPCODE=56: LMP_BT_2.0_REQ
11
1
00001
10111000


FIG. 2



201
PAYLOAD HEADER
PAYLOAD
L_CH
FLOW
LENGTH
OPCODE=4: LMP_NOT_ACCEPTED
11
1
00011
10000100001110000011010
LMP_NOT_ACCEPTED
LMP_BT_2.0_REQ
UNSUPPORTED LMP_FEATURE


FIG. 3

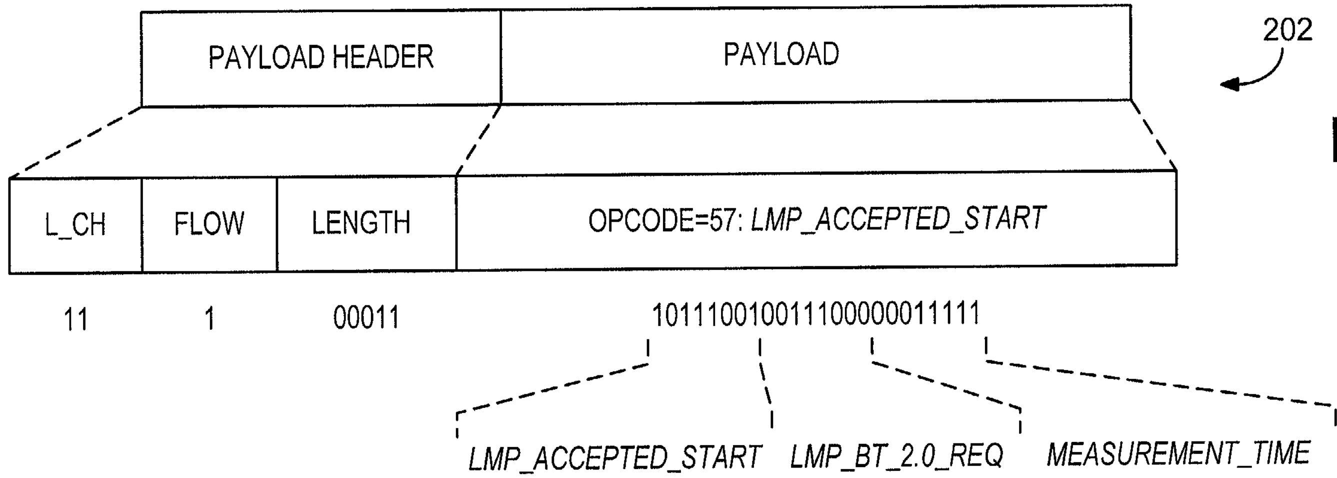

202
PAYLOAD HEADER
PAYLOAD
L_CH
FLOW
LENGTH
OPCODE=57: LMP_ACCEPTED_START
11
1
00011
1011100100111000000011111
LMP_ACCEPTED_START
LMP_BT_2.0_REQ
MEASUREMENT_TIME

FIG. 4

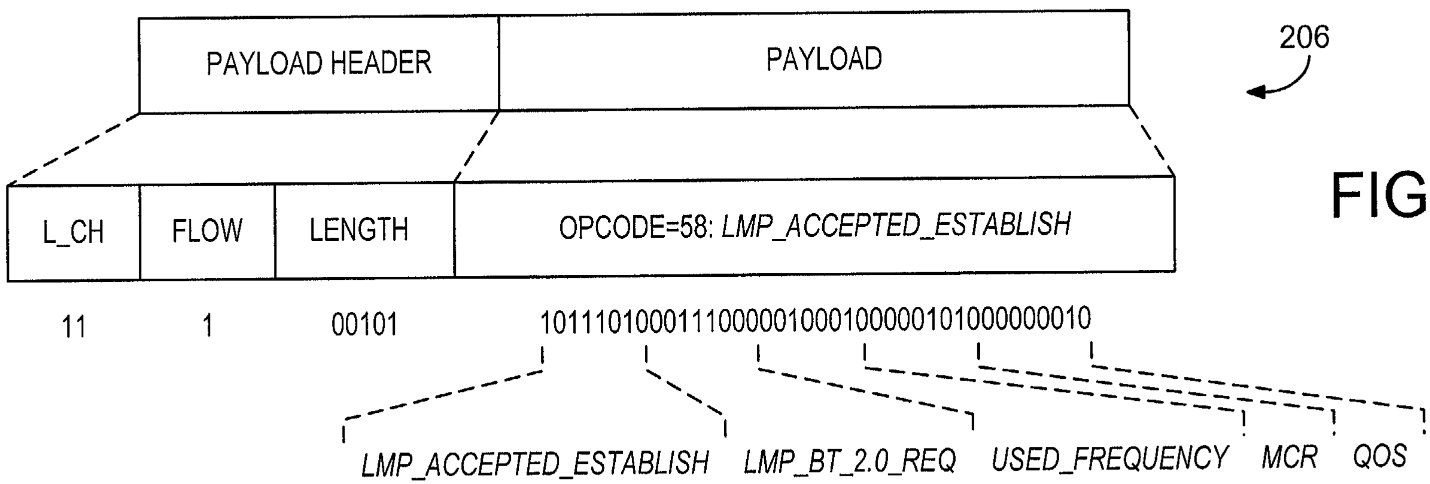
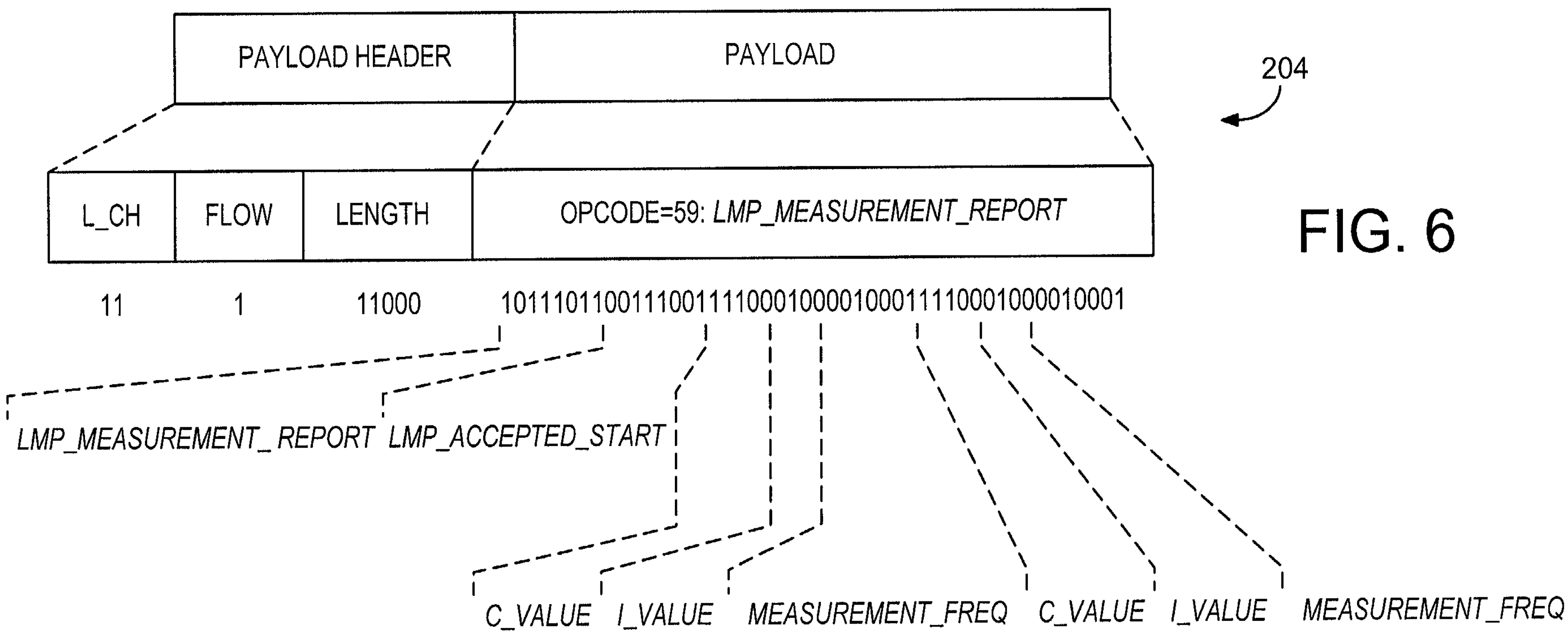
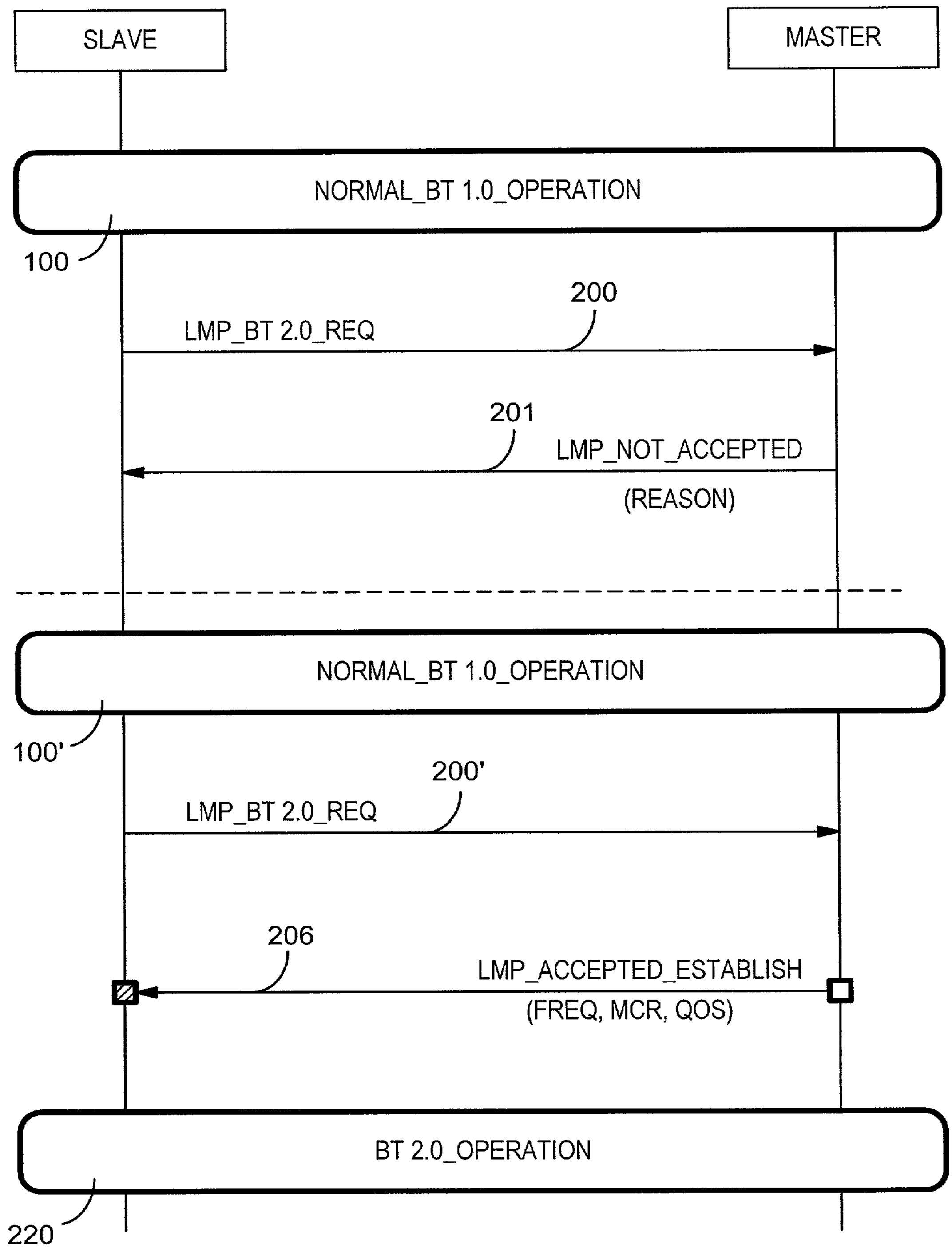

206
PAYLOAD HEADER
PAYLOAD
L_CH
FLOW
LENGTH
OPCODE=58: LMP_ACCEPTED_ESTABLISH
11
1
00101
1011101000111000001000100000101000000010
LMP_ACCEPTED_ESTABLISH
LMP_BT_2.0_REQ
USED_FREQUENCY
MCR
QOS

FIG. 5



PAYLOAD HEADER
PAYLOAD
204
L_CH
FLOW
LENGTH
OPCODE=59: LMP_MEASUREMENT_REPORT
11
1
11000
10111011001110011110001000010001111000100001000‌1
LMP_MEASUREMENT_ REPORT
LMP_ACCEPTED_START
C_VALUE
I_VALUE
MEASUREMENT_FREQ
C_VALUE
I_VALUE
MEASUREMENT_FREQ


FIG. 6



SLAVE
MASTER
NORMAL_BT 1.0_OPERATION
100
200
LMP_BT 2.0_REQ
201
LMP_NOT_ACCEPTED
(REASON)
NORMAL_BT 1.0_OPERATION
100'
200'
LMP_BT 2.0_REQ
206
LMP_ACCEPTED_ESTABLISH
(FREQ, MCR, QOS)
BT 2.0_OPERATION
220


FIG. 7a

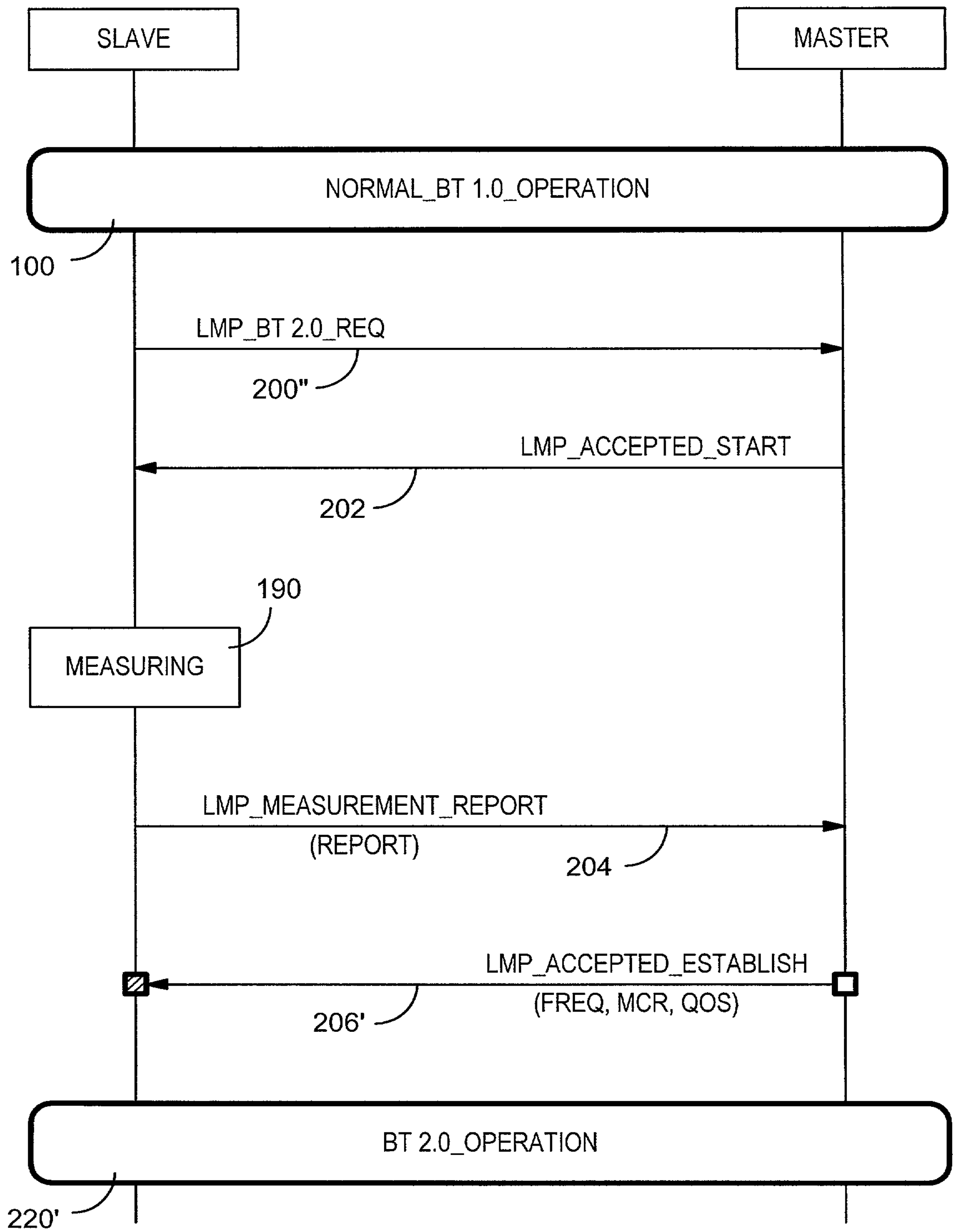
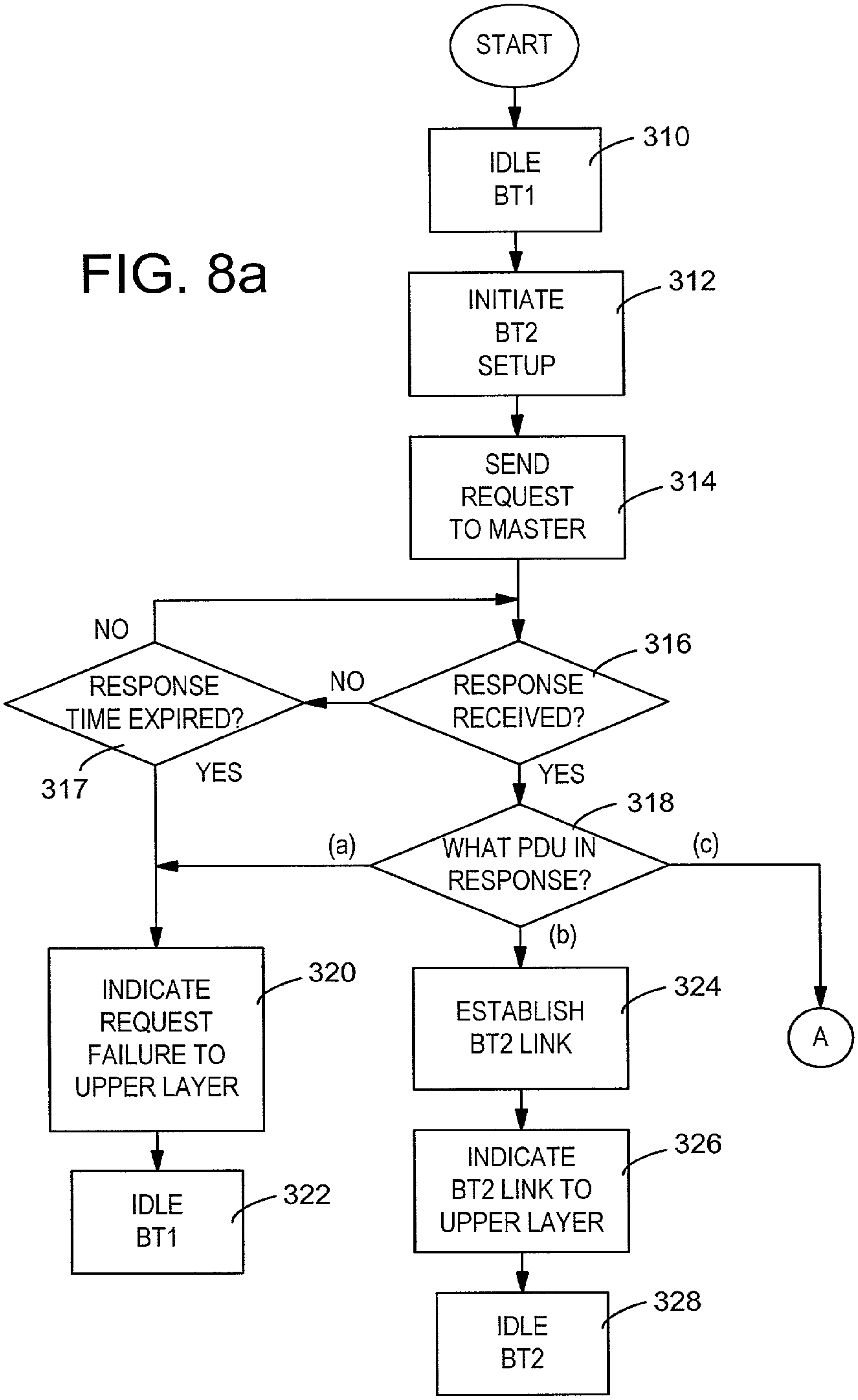

SLAVE
MASTER
NORMAL_BT 1.0_OPERATION
100
LMP_BT 2.0_REQ
200"
LMP_ACCEPTED_START
202
190
MEASURING
LMP_MEASUREMENT_REPORT
(REPORT)
204
LMP_ACCEPTED_ESTABLISH
(FREQ, MCR, QOS)
206'
BT 2.0_OPERATION
220'

FIG. 7b

FIG. 8a


START
IDLE BT1
310
INITIATE BT2 SETUP
312
SEND REQUEST TO MASTER
314
RESPONSE RECEIVED?
316
NO
RESPONSE TIME EXPIRED?
317
NO
YES
YES
WHAT PDU IN RESPONSE?
318
(a)
(b)
(c)
INDICATE REQUEST FAILURE TO UPPER LAYER
320
IDLE BT1
322
ESTABLISH BT2 LINK
324
INDICATE BT2 LINK TO UPPER LAYER
326
IDLE BT2
328
A

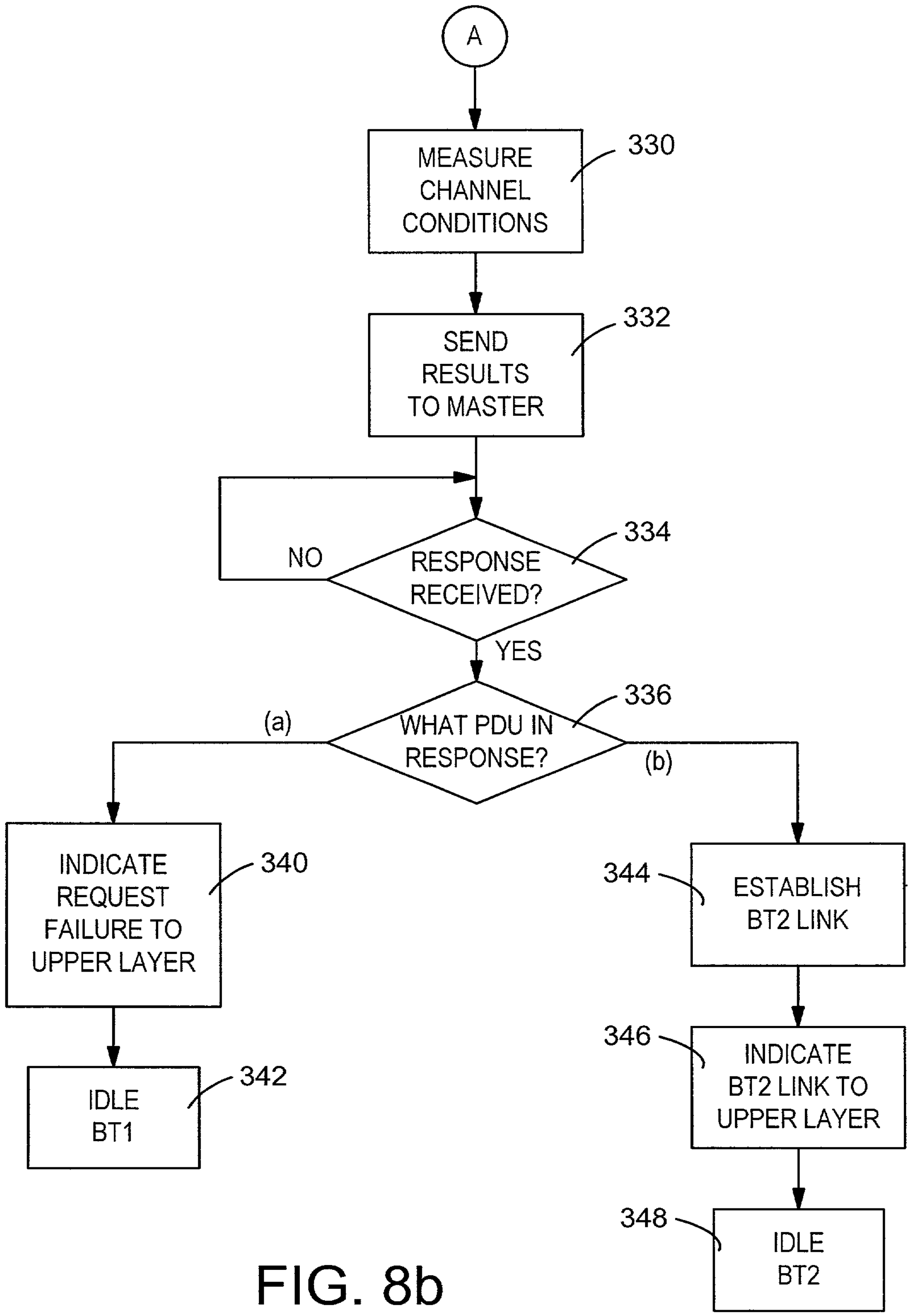
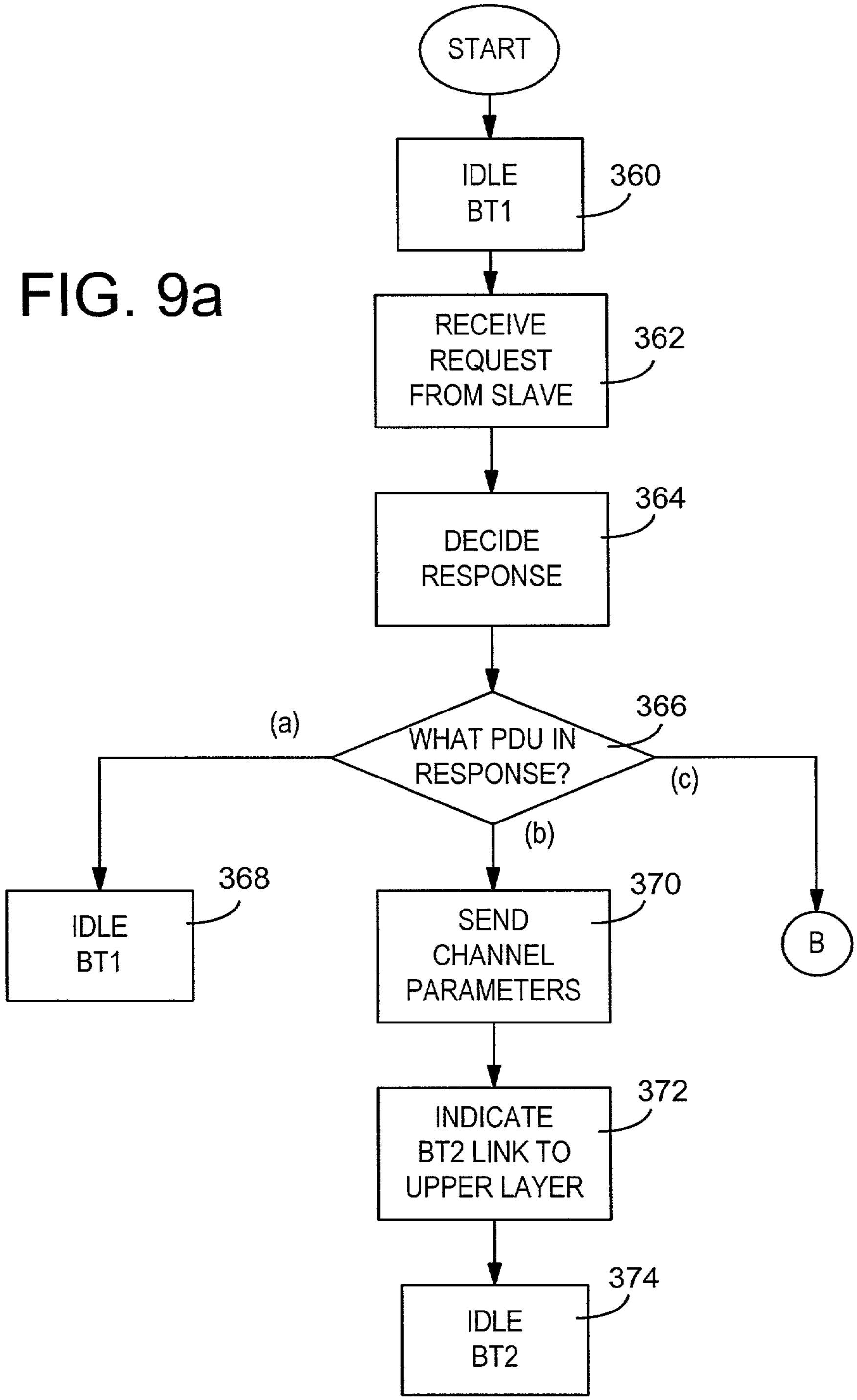

A
MEASURE CHANNEL CONDITIONS
330
SEND RESULTS TO MASTER
332
RESPONSE RECEIVED?
334
NO
YES
WHAT PDU IN RESPONSE?
336
(a)
(b)
INDICATE REQUEST FAILURE TO UPPER LAYER
340
IDLE BT1
342
ESTABLISH BT2 LINK
344
INDICATE BT2 LINK TO UPPER LAYER
346
IDLE BT2
348

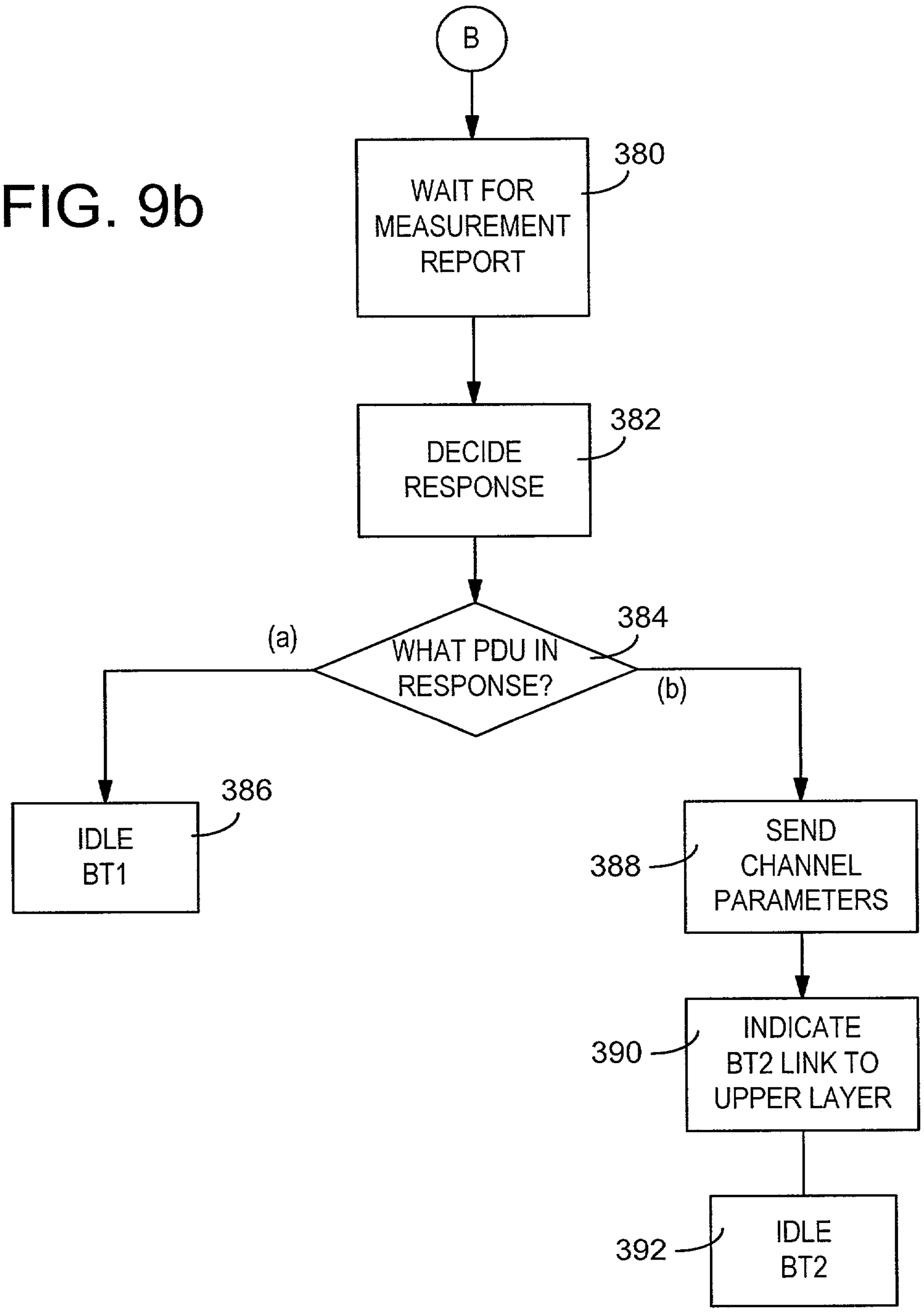
FIG. 8b

FIG. 9a



START
IDLE BT1
360
RECEIVE REQUEST FROM SLAVE
362
DECIDE RESPONSE
364
WHAT PDU IN RESPONSE?
366
(a)
(b)
(c)
IDLE BT1
368
SEND CHANNEL PARAMETERS
370
B
INDICATE BT2 LINK TO UPPER LAYER
372
IDLE BT2
374

FIG. 9b


B
WAIT FOR MEASUREMENT REPORT
380
DECIDE RESPONSE
382
WHAT PDU IN RESPONSE?
384
(a)
(b)
IDLE BT1
386
SEND CHANNEL PARAMETERS
388
INDICATE BT2 LINK TO UPPER LAYER
390
IDLE BT2
392

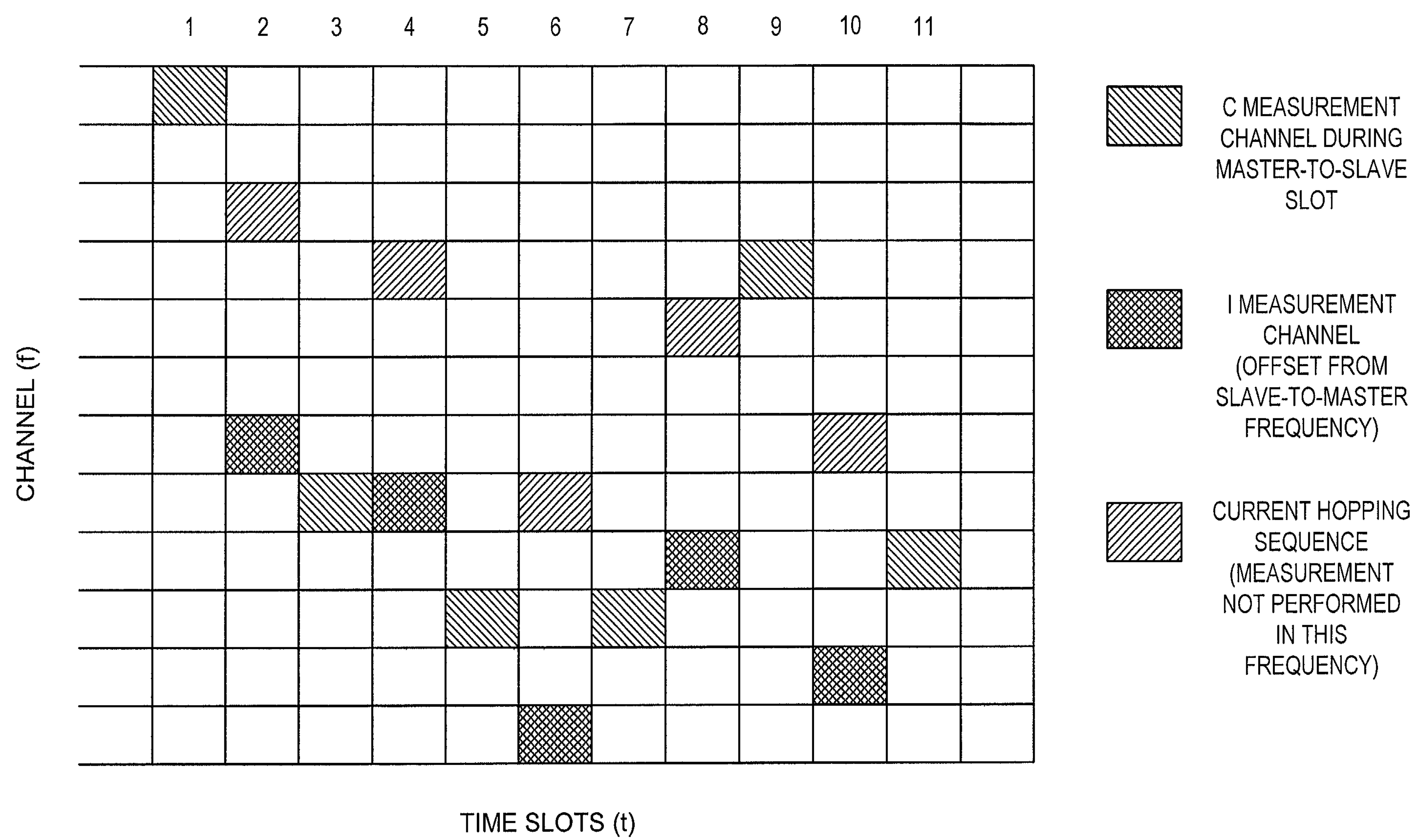
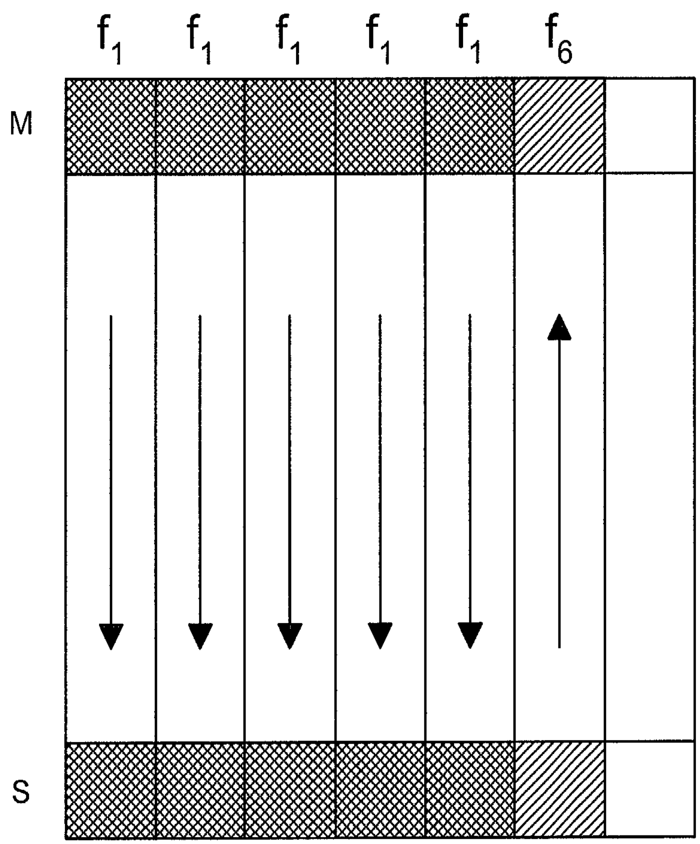
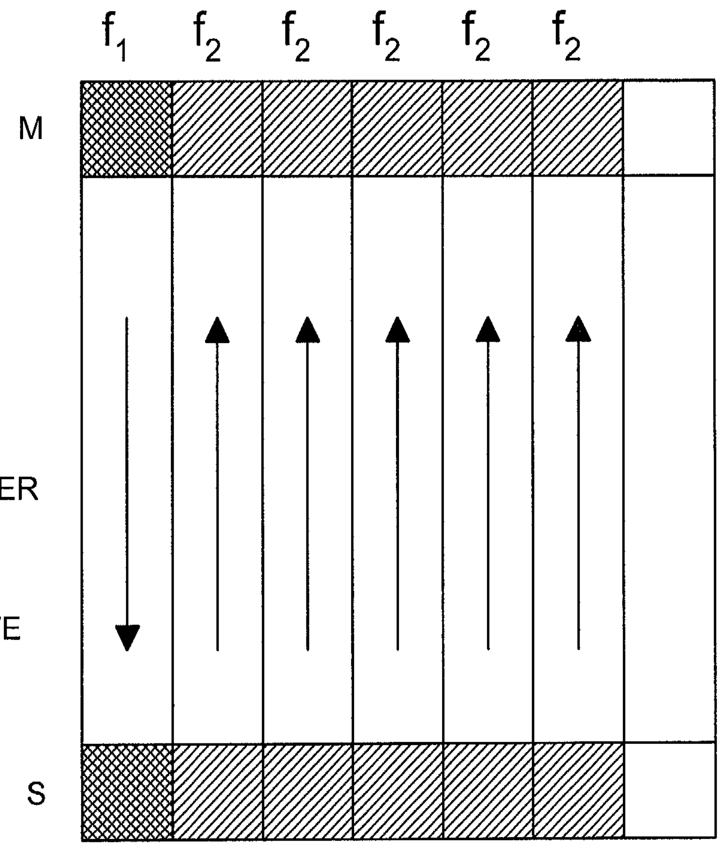

1
2
3
4
5
6
7
8
9
10
11
CHANNEL (f)
TIME SLOTS (t)
C MEASUREMENT CHANNEL DURING MASTER-TO-SLAVE SLOT
I MEASUREMENT CHANNEL (OFFSET FROM SLAVE-TO-MASTER FREQUENCY)
CURRENT HOPPING SEQUENCE (MEASUREMENT NOT PERFORMED IN THIS FREQUENCY)

FIG. 10




M = MASTER

S = SLAVE




MASTER-TO-SLAVE SLOT

SLAVE-TO-MASTER SLOT

$f_n$ = CURRENT HOPPING FREQUENCY

FIG. 11a

FIG. 11b

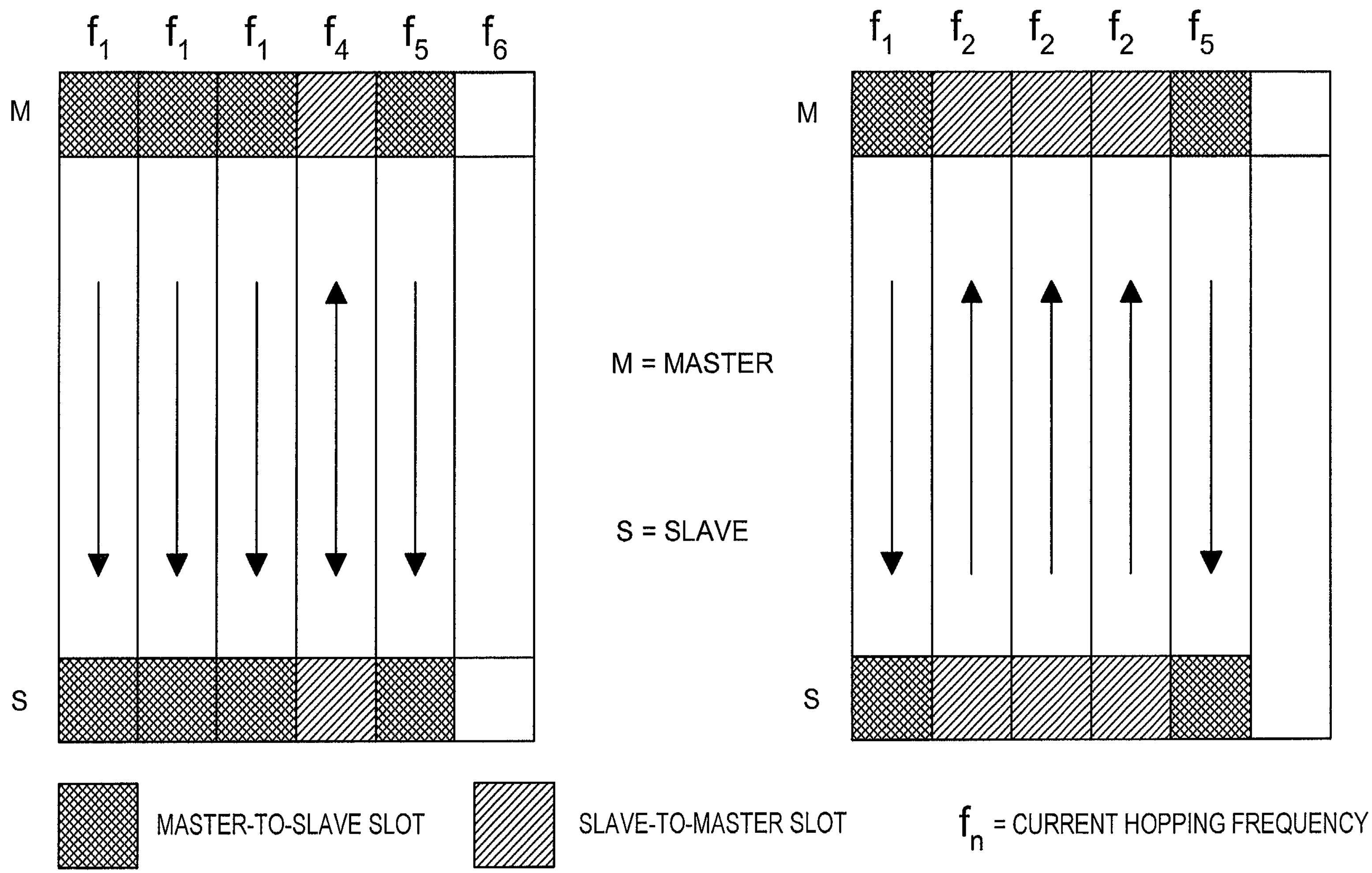



FIG. 12a

FIG. 12b

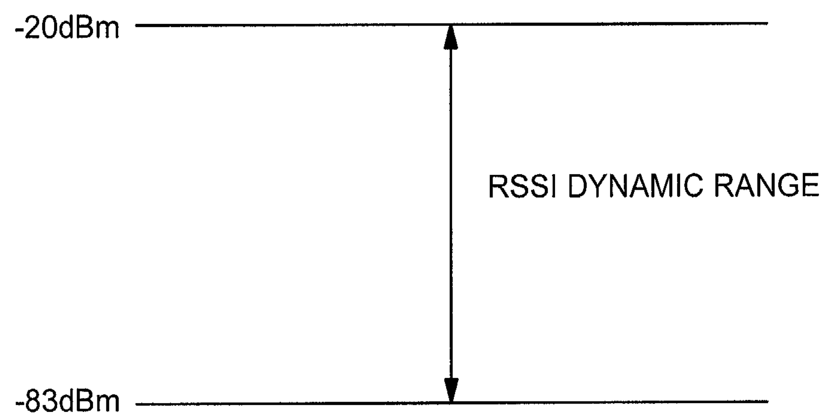



FIG. 13

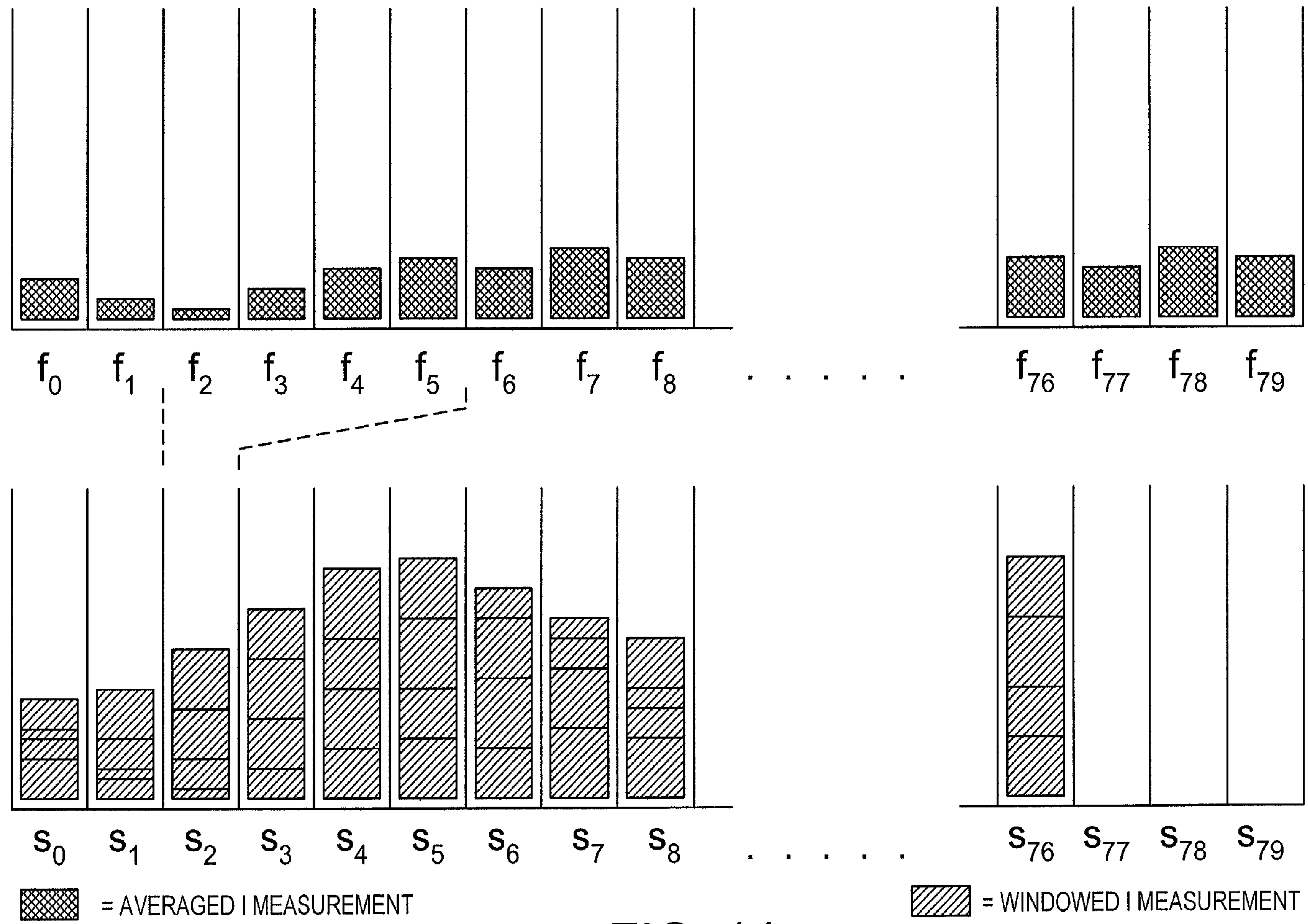

f0 f1 f2 f3 f4 f5 f6 f7 f8 . . . . . . f76 f77 f78 f79
s0 s1 s2 s3 s4 s5 s6 s7 s8 . . . . . . s76 s77 s78 s79
= AVERAGED I MEASUREMENT
= WINDOWED I MEASUREMENT

FIG. 14

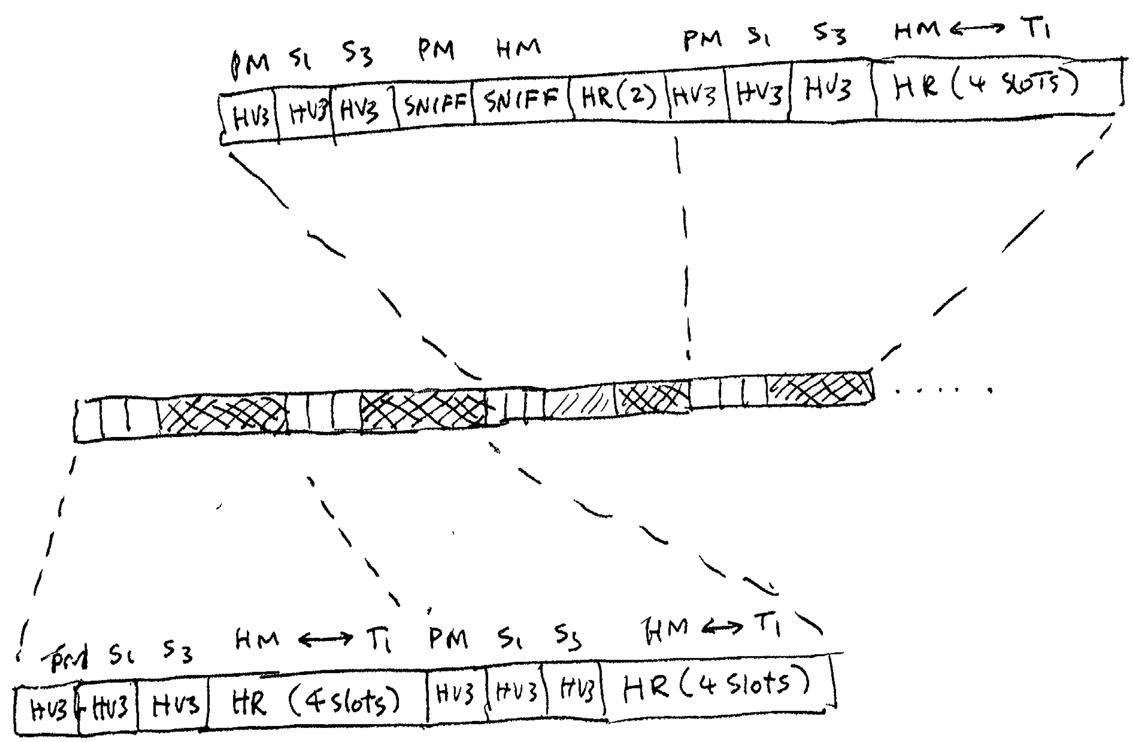

PM S1 S3 PM HM PM S1 S3 HM ⟷ T1
HV3 HV3 HV3 SNIFF SNIFF HR(2) HV3 HV3 HV3 HR (4 SLOTS)
PM S1 S3 HM ⟷ T1 PM S1 S3 HM ⟷ T1
HV3 HV3 HV3 HR (4 slots) HV3 HV3 HV3 HR (4 slots)

FIG. 15a

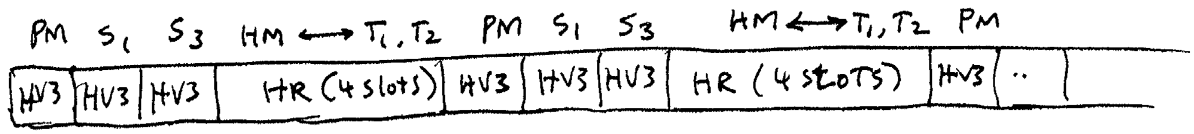



FIG. 15b

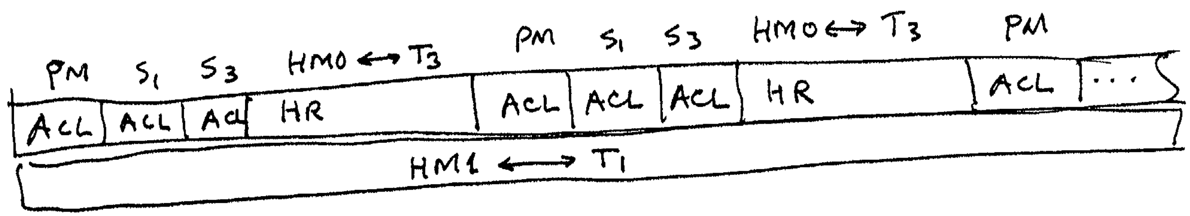



FIG. 15c

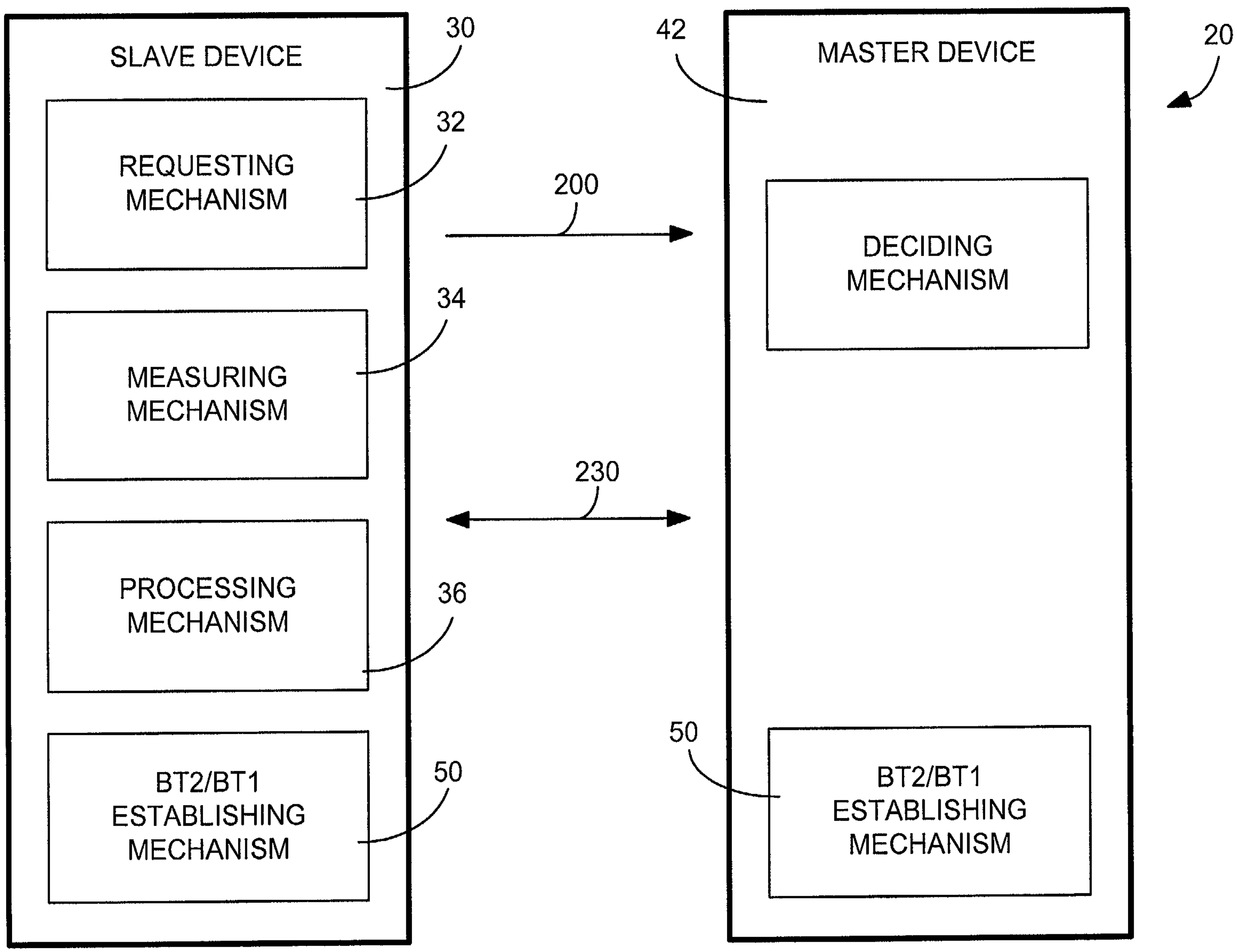

SLAVE DEVICE
REQUESTING MECHANISM
MEASURING MECHANISM
PROCESSING MECHANISM
BT2/BT1 ESTABLISHING MECHANISM
MASTER DEVICE
DECIDING MECHANISM
BT2/BT1 ESTABLISHING MECHANISM
30
32
34
36
50
200
230
42
50
20

FIG. 16